Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/GB05/001125

International filing date: 18 March 2005 (18.03.2005)

Document type: Certified copy of priority document

Document details: Country/Office: GB
Number: 0406272.5
Filing date: 19 March 2004 (19.03.2004)

Date of receipt at the International Bureau: 23 June 2005 (23.06.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

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22MAR04 E882558-1 D02000
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2. Patent application number *(The Patent Office will fill in this part)*	0406272.5	19 MAR 2004
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Patents ADP number *(if you know it)*	8832669001	
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom	
4. Title of the invention	Load-Carrying Apparatus and Methods of Manufacture	
5. Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	MATHYS & SQUIRE ~~100 Gray's Inn Road~~ ~~London WC1X 8AL~~ United Kingdom	120 Holborn London EC1N 2SQ
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Continuation sheets of this form	
Description	37
Claim(s)	16
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11. I/We request the grant of a patent on the basis of this application.

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MATHYS & SQUIRE 19 March 2004

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Load-Carrying Apparatus and Methods of Manufacture

The present invention relates to the field of load-carrying apparatus, for example for the storage and transportation of goods, including methods for manufacturing such apparatus. In particular, but not exclusively, the invention relates to apparatus such as freight containers, pallets and cable reels and methods for manufacturing the apparatus.

Apparatus for storing and transportation of goods, particularly bulk goods, has to be robust enough to withstand the high impact stresses and adverse environmental conditions that it may encounter during normal operation.

Freight containers, for example shipping containers, are well known in the art and are used to transport freight securely and conveniently. To ensure containers can withstand the corrosive environment and the temperatures and stresses to which a container may be subjected in normal operation, the requirements for such containers are strictly defined by industry standards such as ISO 1496-1:1990 and ISO 668:1995 and, as required by the standard, prior art containers are manufactured from steel and/or aluminium.

However, steel containers suffer from a number of disadvantages. In particular, the weight of the container itself must be included when considering the gross laden weight for transport purposes and the high density of steel may mean that a large proportion of the weight of the laden container comprises the container itself.

Since the structural integrity and reliability of a steel container is very important, the working life of a steel container is often short, for example about 5 years, or about 7-10 years if the container owner is willing to repair and maintain the container, although it is often not efficient to do so. Steel containers require painting to protect them from rust, particularly in the corrosive environment in which they often operate, for example they maybe subject to salt water during shipping and may encounter

corrosive chemicals or oils during use. Containers may also be subject to high temperatures, particularly during shipping, for example temperatures of up to about 50°C are not uncommon, and steel containers easily absorb this heat and conduct it to their contents and surrounding containers. This may damage the contents of the containers and may make it more difficult to maintain refrigerated containers at a low temperature.

An additional problem with steel containers is that it is difficult to determine or verify the contents of a container without opening the container to view the contents. It is not possible to use remote imaging techniques, such as X-rays, to determine the contents of the container remotely and to ensure that nothing is hidden in the container. Hence it is difficult to detect containers that constitute a security risk or that are being used to transport illicit or undesirable goods.

Aspects of the invention are set out in the independent claims and preferred features are set out in the dependent claims.

According to one aspect there is provided a rotationally-moulded load-carrying apparatus for carrying a load of at least 50 kilograms, wherein the apparatus is manufactured substantially from a filled plastics material comprising:
at least 10% by weight of a polymer;
at least 10% by weight of a mineral filler material.

In some cases, up to 90% by weight of the remainder of the composition may comprise filler. However, a number of other components may be included in the composition. In particular, a component to unify the polymer and the filler may be provided, or a unifier may be present in the filler or polymer. Preferably at least 1% by weight and less than 20% by weight unifier is provided. Further components that may be incorporated in the material include a colourant, a flame retardant and a stabiliser, for example a UV stabiliser.

Manufacturing load-carrying apparatus using a plastics based material may provide

a number of advantages, as set out in more detail below. However, it has been found that containers manufactured substantially from a purely plastics material are not sufficiently resilient to withstand the temperatures and stresses to which they may be subjected during normal use. The addition of a filler may solve this problem by increasing the strength and structural integrity of the apparatus.

Forming the apparatus from a plastics material may be advantageous since the unladen weight of the plastic apparatus may be less than that the equivalent prior art apparatus, which may be manufactured from materials such as steel or wood. This may allow a user to use the apparatus to carry a greater weight of goods, whilst keeping the gross weight constant, or may allow a transportation operator, for example a shipping merchant, to pack more load-carrying apparatus onto a ship or to save fuel in transportation of the apparatus.

In addition, apparatus manufactured from a plastics based material will not suffer from the problems associated with rusting and hence such apparatus may not require painting. These properties may enable the expected lifetime of the apparatus to be increased. For example, the expected lifetime of a prior art steel shipping container may be about 5 years for a steel container whereas a lifetime of about 25 years is reasonable for a plastics-based container. A further advantage may be that, when the plastic apparatus is brought out of operation, it may be broken up and ground and the material may be incorporated into new products, for example the material may be recycled to form parts of new apparatus.

A further advantage of such apparatus is that it may be possible to determine, verify or monitor the contents of the apparatus using a remote sensing technique, such as X-rays or thermo-sensing, since it may be possible for such radiation to pass through the material of the apparatus. This may allow authorities to ensure that the contents of the apparatus do not comprise a security risk and may allow authorities to detect illicit or undesirable goods or to verify that the contents of the apparatus correspond to the declared contents.

A further property of the apparatus may be that the plastics material has better insulating properties than the material used for the equivalent prior art apparatus, for example steel. This may allow the contents of the apparatus to be better insulated from high or low temperatures than in the prior art apparatus. This may enable, for example, refrigerated containers to be provided more easily and such containers may require less power to be maintained at a constant temperature.

Rotationally moulding the apparatus may allow the apparatus to be formed with few internal stresses in the material. This may lead to a stronger load-bearing apparatus than would be provided by other forms of moulding.

Preferably, the mineral material comprises a silicate or comprises a carbonate material. In a highly preferred embodiment, the filler comprises sand, preferably consists essentially of sand. The sand is preferably dredged sand. Sand is readily available at consistent granularity and can form a surprisingly effective filler. Another advantage of using sand as part of the filler material is that it may provide additional security for the container, since container walls that include sand may be difficult to cut through, since the sand in the composition is likely to blunt quickly any machinery that is used to attempt to cut through the material. In an alternative embodiment, the filler may comprise calcium carbonate.

Further, the filled material described herein is likely to be flame retardant, although a further flame retardant component may also be incorporated into the filled material.

In a preferred embodiment, the polymer comprises polyethylene. The polymer used may depend on the apparatus being manufactured and other polymers, such as PVC or PVA may be used. However, polyethylene may provide a hard-wearing, resistant material for use in a wide range of apparatus.

More preferably, the polymer comprises High Density Polyethylene (HDPE). Preferably, the material comprises at least 25% by weight filler.

Preferably, the material comprises at least 25% by weight polymer.

In a highly preferred embodiment, the material comprises from about 30% to about 70% by weight polymer and from about 70% to about 30% by weight filler. The polymer and the filler may comprise 100% of the material or other components may be included in the material as described herein and the additional components may comprise the remaining % weight of the material.

In a preferred embodiment, the filled plastics material further comprises a unifier. The unifier may be provided to bind the polymer and the filler together.

Preferably, the filled plastics material comprises at least about 0.1% by weight unifier. Preferably, the filled plastics material comprises less than about 10% by weight unifier.

More preferably, the filled plastics material comprises at least about 0.25% by weight unifier. More preferably, the filled plastics material comprises less than about 5% by weight unifier.

In a preferred embodiment, the unifier is pre-mixed with the filler before the filler is mixed with the polymer.

In one embodiment, the unifier may comprise an internal lubricant. Alternatively or additionally, the unifier may comprise an external lubricant. The internal lubricant may act to improve lubrication between the polymer chains.

In a preferred embodiment, the internal lubricant comprises a fatty acid amide. More preferably, the internal lubricant comprises a straight or branched C_{12}-C_{24} fatty acid amide. More preferably, the internal lubricant comprises steramide.

In a preferred embodiment, the external lubricant comprises a stearate.

Preferably, the unifier comprises less than 20% by weight internal lubricant. More preferably, the unifier comprises about 10% by weight internal lubricant.

Preferably, the filler comprises at least one of:
a silicate material, preferably sand;
ash;
a carbonate material, preferably calcium carbonate;
a salt, preferably sodium chloride.

The filler may comprise a mixture of filler materials. Preferably, the filler material is inert, more preferably the filler material is inorganic, although organic fillers, such as wood flour, peanut hulls, ground straw or animal litter may be used. Preferably, the filler is provided or is ground into small particles, since this may provide a more uniform material. Dredged sand may be used in preference to desert sand since the particles of dredged sand are finer than those of desert sand.

In a preferred embodiment, the apparatus is rotationally moulded substantially in one piece. Moulding the apparatus substantially in one piece may advantageously allow the product to be produced without substantial post-processing of the moulded product. Parts of the apparatus (for example, the doors of a container) may be moulded separately and coupled to the apparatus after the main moulding process.

In one embodiment, the apparatus comprises a freight container. A freight container manufactured as described herein may provide the advantages outlined above. In particular, the plastics container may be lighter and may be more durable and more environmentally sustainable than a prior art steel container. In addition, it may be possible to X-ray or obtain a thermal image of the plastics container to determine its contents and increase security.

In one embodiment the freight container comprises an elongate freight container having a length of at least 5m, e.g. e.g. the container may comprise a 20 foot (about 6m) container.

In a further embodiment, the freight container may comprise an elongate freight container having a length of at least 10m, e.g. the container may comprise a 40 foot (about 12m) high-cube container. This may allow the container to be used in the same way as an existing steel container that meets the standards for a 40' high cube container. For example, the plastics 40' container may be stacked with prior art containers and may be transported using the same apparatus and fixing means as a prior art container, for example the container may be fixed onto a transport lorry in the same way as a prior art container. As will be appreciated by one skilled in the art, however, the container may comprise storage and transportation apparatus of any shape or size.

Preferably, the thickness of the walls of the container is less than about 90mm. Hence the container may have thinner walls than a prior art steel container. In one embodiment, the walls may have a thickness of about 70mm.

Preferably, the filler comprises a light-coloured material. This may enable the apparatus to be manufactured in a light colour without requiring painting or expensive pigments. For a container, manufacturing the container in a light colour may help the container to maintain a lower temperature when it is exposed to high temperatures, particularly to radiated heat such as intense sunlight.

In one embodiment, the apparatus comprises a pallet. A plastics-based pallet may advantageously provide an alternative to the prior art wooden pallets. The plastic pallet may have a longer usable life than a wooden pallet, since the plastic pallet may be stronger and more durable that a wooden pallet. Hence the plastic pallet may be more environmentally sustainable than a wooden pallet.

Preferably, the pallet is moulded substantially in one piece. Preferably, a plurality of pallėts may be moulded in a single moulding operation.

Preferably, the pallet comprises a platform and a plurality of feet depending from the

platform.

More preferably, the feet are arranged to enable lifting equipment to engage the pallet from any one of four directions. Hence the pallet may be a four-way-access pallet, which may be lifted from any one of four directions, for example by a fork-lift truck.

Preferably, the feet of the pallet are regularly spaced over the lower surface of the platform. Bracing members may be provided between the feet of the pallet.

Preferably, at least one foot is arranged substantially at each corner of the platform of the pallet. Hence, each corner of the platform may be supported.

More preferably, at least one foot is arranged substantially at the centre of the platform of the pallet. This may further strengthen the platform pallet at the centre.

Preferably, at least one foot is arranged substantially at the centre of each edge of the platform of the pallet. Hence a total of 9 feet are preferably provided for each pallet. Four feet may be provided at the corners of the pallet, a further four feet may be provided at the centre of each edge of the pallet and a further, 9th foot may be provided under the centre of the platform of the pallet.

In a preferred embodiment, each foot has a recess in the lower surface of the foot. This may advantageously reduce the weight of the pallet, without reducing the strength of the pallet. In addition, the pallet may be formed without requiring a large cavity in each foot to be evenly filled with an inner layer.

Preferably, the pallet comprises an outer skin layer having an upper surface and a lower surface.

More preferably, the upper and lower surfaces of the outer skin layer are arranged to abut each other over at least a portion of the pallet surface. In one embodiment, the

upper and lower surfaces may form a cavity over the feet of the pallet but may abut each other, e.g. the surfaces may be formed substantially without a gap between them, over the platform areas of the pallet. The outer skin layer may be the only layer of the pallet and the cavities formed between the upper and lower surfaces may be filled with air. Alternatively, the cavities may be filled with a further material, such as a foamed plastics material or a filled plastics material.

In a preferred embodiment, the pallet further comprises an inner layer having a different composition to the outer skin layer. Providing an inner layer within the outer skin may add further strength and rigidity to the pallet.

Preferably, the inner layer comprises a foaming agent. Providing the layer as a foam layer may ensure that the additional layer does not add significantly to the overall weight of the pallet.

In an alternative embodiment, the inner layer comprises at least 40% by weight of a filler. Using a highly filled inner layer may enable the pallet to be strengthened, but the highly-filled layer may be inexpensive.

In a preferred embodiment, the feet of the pallet are moulded integrally with the platform.

Preferably, the pallet has a length of at least 800mm. In one embodiment, the pallet may have dimensions corresponding to those of a standard pallet, that is about 1020x1220x120mm (40x48x5 inches).

Preferably, the feet of the pallet have a width greater than about 30mm.

In a further embodiment, the apparatus comprises a cable reel.

In a highly preferred embodiment, the apparatus comprises a plurality of layers.

Preferably, the composition of the filled plastics material differs between the layers. This may allow properties of a plurality of compositions to be incorporated into the apparatus.

Preferably, the composition of a first layer of the apparatus is optimised to provide an outer skin layer. Preferably, the outer skin layer is manufactured to be durable enough to withstand the conditions and the chemicals to which the apparatus may be subjected during normal use.

Preferably, the outer skin layer comprises more than about 20% by weight filler. More preferably, the outer skin layer comprises less than about 80% by weight filler. This may ensure that the outer skin layer is not too brittle.

Preferably, the outer skin layer comprises more than about 50% by weight polymer, more preferably, the outer skin layer comprises about 60% by weight polymer.

In a preferred embodiment, the composition of a second layer of the apparatus is optimised to provide an inner layer. The inner layer may be formed within the outer skin layer and may comprise a highly-filled or a light-weight layer.

In a preferred embodiment, the inner layer comprises a polymer. Hence the inner layer may not contain a filler material. This may be advantageous since a polymer, particularly a foamed polymer, may be lighter than a filled polymer.

In an alternative embodiment, the inner layer comprises a polymer and a filler.

In one embodiment, the inner layer comprises more than about 30% by weight filler. A highly-filled inner layer may be provided, since it will be protected by the outer skin layer. Hence the inner foam layer may have different surface properties to the outer skin layer, since it will not be subjected to external conditions. A highly filled, relatively dense, inner layer may be provided inexpensively, for example using a low-grade filler.

More preferably, the inner layer comprises more than about 50% by weight filler. In a preferred embodiment, the inner layer comprises about 60% by weight filler.

In a preferred embodiment, the inner layer comprises a greater amount of filler by weight than the outer layer.

In a highly preferred embodiment, the inner layer comprises a foaming agent, preferably the foam layer is about 50% foamed. This may mean that the inner layer is a light layer and does not increase significantly the overall weight of the apparatus.

In some embodiments, the filled plastics material further comprises a pigment. Advantageously, the apparatus may be coloured to any colour required simply by adding a pigment to the feedstock. This may allow apparatus of a consistent colour to be produced without requiring the further step of painting the apparatus. In some embodiments, the product formed from the material, for example the container or the pallet, may further be printed on.

In a preferred embodiment, the apparatus incorporates a remotely readable Identification (ID) tag, preferably an RFID tag. The tag may be used to store information about the container and/or the contents of the container. For example, details of the contents of the container, its source, its destination, and the owner of the contents of the container may be recorded.

Preferably, the ID tag is moulded into the surface of the apparatus.

In some embodiments, the filled plastics material further comprises a stabiliser, preferably a UV stabiliser. This may allow the material to be exposed to Ultra-Violet radiation, for example sunlight, without degrading the plastics material.

In some embodiments, the filled plastics material further comprises a plasticizer.

According to a further aspect, there is provided apparatus for sealing a freight container comprising sealing means manufactured from a plastics material, wherein the plastics material is soluble in salt-water.

A problem in the container freight shipping industry is that containers are often lost overboard from container ships. The lost containers often contain air and other matter less dense than water and, since the containers are substantially air-tight, the containers may float on or just below the surface of the water. This may cause a hazard for other shipping in the area. The aspect described above may therefore allow a container lost overboard to lose its seal, to fill with water and to sink, which may reduce or remove the potential hazard caused by the container.

Preferably, the plastics material comprises PVA or PVOH.

Preferably, the plastics material further comprises a filler and/or a unifier.

Preferably, the seal is arranged to dissolve in salt water over a period of about 5 days.

According to a further aspect, there is provided a method of manufacturing apparatus for storage or transportation of loads greater than about 50 kilograms, the method comprising rotationally moulding the apparatus from a filled plastics material comprising a polymer, a filler and a unifier.

According to a further aspect, there is provided X-ray apparatus for forming an X-ray of the contents of a load-carrying apparatus for carrying loads of at least 50 kilograms and manufactured from a filled plastics material, comprising:
a scanning area;
energy delivery means for providing energy of a suitable frequency spectrum and intensity to penetrate at least 20mm of the filled plastics material;
energy detecting means to detect reflected energy.

According to a further aspect, there is provided thermal imaging apparatus for forming a thermal image of the contents of a load-carrying apparatus for carrying loads of at least 50 kilograms and manufactured from a filled plastics material, comprising:
a scanning area;
energy detection means for detecting thermal energy transmitted from within the load-carrying apparatus.

Preferably, the scanning area has a maximum dimension of at least 1m. In one embodiment, the scanning area has a maximum dimension of at least 2m.

Preferably, the filled plastics material comprises at least 10% by weight of a mineral filler, preferably a silicate or a carbonate filler.

In one embodiment, the load-carrying apparatus comprises a freight container. Hence the contents of containers may be determined using the imaging apparatus.

In one embodiment, the load-carrying apparatus has a length of at least 5m. In a further embodiment, the load-carrying apparatus has a length of at least 10m.

A further aspect provides a method of rotationally moulding a product from a filled plastics material comprising:
providing a mould for the product defining a void corresponding to at least a portion of the required shape of the product;
loading a first feedstock having a first composition comprising a polymer and at least 10% by weight of a mineral filler into the mould;
heating the mould;
rotating and/or rocking the mould about at least two axes to coat the internal walls of the mould with a layer of the first feedstock;
cooling the mould;
releasing the product from the mould.

The method described above may advantageously provide an efficient method of rotationally moulding products.

Preferably the method further comprises providing heating means adjacent to the walls of the mould and heating the mould using the heating means. Applying heat using heating means adjacent to the walls, such as one or more burners, for example gas or oil burners, or one or more electric heated plates, may allow the mould to be heated evenly over its whole surface without requiring the mould to be placed in and rotated within an oven. Hence the mould may be heated more quickly, since it is not necessary to heat a whole oven and the energy-efficiency of the process may also be increased.

Preferably, the method comprises providing cooling means adjacent to the walls of the mould and cooling the mould using the cooling means. Similarly, providing cooling means adjacent to the walls, such as a stream or jet of water or cooled air, may increase the energy efficiency and decrease the moulding time for the product, since the mould may be cooled directly, without requiring a moulding oven to be cooled.

In addition, using heating and cooling means adjacent to the mould walls may allow moulds of any size or shape to be used without the user requiring a moulding oven of a corresponding size.

Preferably, the heating means comprise a plurality of burners. Preferably, the burners comprise gas or oil burners.

Preferably, the cooling means comprises at least one supply of water, for example, a stream, a pool or a jet of water.

Preferably, the mould is a generally elongate mould and the method comprises rotating the mould about a first axis substantially parallel to the axis of elongation of

the mould and rocking the mould about a second axis substantially orthogonal to the first axis.

In a preferred embodiment, rocking the mould comprises rocking the mould through a portion of a circle to a maximum angle from the horizontal of less than about 30°. Preferably, the mould is rocked to a maximum angle from the horizontal of about 15°. In some embodiments, particularly if the mould is a small mould, the mould may be rocked to an angle greater than about 30°, for example the mould may be rocked to about 45°.

Preferably the mould is rocked at a rate of less than about 6 rocking cycles per minute. Preferably, the mould is rocked at a rate of about 4 cycles per minute.

Preferably, the mould is rocked at a rate of greater than about 1 rocking cycle per minute.

Preferably rotating the mould comprises rotating the mould at a rate of less than about 10 revolutions per minute. More preferably around 4 revolutions per minute. Preferably, rotating the mould comprises rotating the mould through 360°. Alternatively, the mould may not be rotated through a full circle. The mould may be constantly rotated in the same direction, or the direction of rotation may be reversed periodically.

In some embodiments, particularly if the mould is a small mould, the mould may be rocked and/or rotated at a faster rate. However, except for small moulds, the cycle rate is likely to be less than about 30rpm.

Using a rotation or rocking rate that is too slow may lead to an uneven distribution of feedstock within the mould, since gravitational effects may dominate the motion of the feedstock. However, using a rotation or rocking rate that is too fast may not be energy-efficient and centrifugal effects may also lead to an inferior product.

Hence it is preferably not necessary to rotate or to rock the mould at a high rate. The rotating and rocking of the mould is preferably a continuous motion, but may not be continuous in some embodiments.

In a preferred embodiment, the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion. Hence the product may be formed between the two moulds. This may allow the inner surface of the product to be provided with a predetermined shape and may allow the thickness of the product to be controlled. The feedstock is preferably inserted between the moulds and the moulds are heated and rotated together to ensure that the melted feedstock covers the surfaces of both of the moulds.

Preferably, the method further comprises providing heating means within the inner mould portion. Hence the inner mould portion may be heated to provide a more even temperature distribution throughout the moulding volume.

Preferably, the method further comprises maintaining the heating means at a substantially constant distance from the walls of the outer mould portion as the mould is rotated. This may enable all parts of the mould to be heated evenly and hence may encourage a more even distribution of the plastics material within the mould.

Preferably, the method further comprises, before cooling the mould:
loading a second feedstock, having a second composition, into the mould;
rotating the mould to form a second layer of the second feedstock.

Preferably, the composition of the first layer is optimised to provide an outer skin layer.

Preferably, the composition of the second layer is optimised to provide an inner

layer.

In a preferred embodiment, the second feedstock comprises a foaming agent. Preferably, the second feedstock becomes foamed after insertion into the mould on the application of heat to the mould. Hence the feedstock may be distributed evenly within the mould before being foamed. Aeration of the feedstock may release nitrogen or another similar, preferably substantially inert gas. Preferably, a foaming agent, such as sodium bicarbonate, may be incorporated into the second feedstock.

Preferably, the second feedstock comprises a higher proportion of filler than the first feedstock. In one embodiment, the second feedstock comprises at least 50% by weight of a mineral filler. However, as described for the pallet above, the second feedstock may not contain a filler but may simply be a polymer, preferably a foamed polymer. Alternatively, the second feedstock may be highly filled.

The mineral filler preferably comprises a silicate filler, such as sand, or a carbonate filler, such as calcium carbonate.

In one embodiment, the product may comprise at least one of: a freight container, a pallet, a cable reel or a panel. Preferably, a plurality of products are produced in a single moulding operation.

In one embodiment, the method may further comprise positioning elements of the product within the mould before the feedstock is inserted and over-moulding the elements into the product. This may further reduce the amount of post-processing required for the product and ensure that the additional components are securely fixed into the product.

In one embodiment, the product comprises a freight container and the elements comprise one or more of:
a metal frame;
door securing means;

strengthening elements; or
corner lifting elements.

In a highly preferred embodiment, the product is moulded substantially in one piece.

Preferably, releasing the product from the outer mould portion comprises moving the walls of the outer mould portion apart and away from the moulded product. Hence the outer mould portion may be removed from the moulded product and the product may be removed from the inner mould portion. This may advantageously allow the product to be formed with shaper and more well-defined edges, since prior art moulding techniques have previously required the product to be removed from a tightly-fitting mould, so it has been necessary to form products with rounded edges to allow the product to be removed from the mould more easily.

A further aspect may provide a filled plastics material comprising:
a polymer;
at least 10% by weight of a mineral filler;
a unifier comprising stearate.

Preferably, the unifier further comprises an internal lubricant, preferably steramide.

More preferably, the steramide comprises Chrodamide S Powder.

Preferably, the stearate comprises Calcium Stearate.

Preferably, the unifier comprises more than 5% by weight steramide. More preferably, the unifier comprises about 10% by weight steramide.

Preferably, the unifier comprises more than 80% by weight stearate. More preferably, the unifier comprises about 90% by weight stearate.

In a preferred embodiment, the polymer comprises polyethylene. More preferably,

the polymer comprises High Density Polyethylene (HDPE).

Preferably, the filler comprises at least one of:
a silicate material, preferably sand;
ash;
a carbonate material, preferably calcium carbonate;
a salt, preferably sodium chloride.

A mixture of filler materials may be used, as described above.

Preferably, the filled plastics material comprises at least 0.1% by weight unifier. More preferably, the filled plastics material comprises about 1% by weight unifier.

According to a further embodiment, there is provided apparatus for rotationally moulding, from a filled plastics material, a load-carrying apparatus for carrying a load of at least 50 kilograms, the apparatus comprising:
a mould defining a void corresponding to at least a portion of the required shape of the product;
means for receiving a first feedstock comprising a filled plastics material comprising a polymer and at least 10% by weight of a mineral filler;
heating means;
cooling means;
means for rotating and/or rocking the mould about at least two axes.

Preferably, the heating means are provided adjacent to the walls of the mould.

Preferably, the cooling means are provided adjacent to the walls of the mould.

In a preferred embodiment, the mould is a generally elongate mould and the apparatus further comprises means for rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and means for rocking the mould about a second axis substantially orthogonal to the first axis.

Preferably, the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion.

Preferably, the apparatus further comprises heating means within the mould, preferably within the inner mould portion.

In a preferred embodiment, the apparatus further comprises means for maintaining the heating means at a substantially constant distance from the mould.

In one embodiment, the outer mould portion has a length of at least 5m. Preferably, the outer mould portion has a length of at least 10m.

Preferably, the filled plastics material comprises at least 30% by weight of a mineral filler. Preferably, the filler comprises a silicate or a carbonate material.

Preferably, the apparatus is mounted over a pit and wherein at least one end of the outer mould portion is rocked into the pit.

Preferably, the means for receiving the feedstock comprises a series of apertures in the outer mould portion. Using a plurality of apertures may allow the feedstock to be inserted into the mould at a high rate. This may decrease the moulding cycle time and may reduce the amount of energy used in each moulding cycle. The feedstock may also be distributed more evenly throughout the mould. Using a series of apertures may be particularly advantageous when the second and any subsequent feedstocks are inserted, since the second feedstock may be inserted quickly an evenly within the first feedstock.

Preferably, the series of apertures is formed along at least one edge of the outer mould portion.

More preferably, the series of apertures is covered by at least one sliding gate valve.

According to a highly preferable embodiment, the internal surface of the sliding gate valve is coated in a non-stick material. This may allow a second or subsequent feedstock to be inserted within a first moulded feedstock. For example, an inner layer of a product may be inserted within an outer shell layer. This may be achieved since the first feedstock preferably does not adhere to the non-stick material, so an aperture in the feedstock layer may be provided when the gate is opened to allow the second feedstock to be inserted.

In a preferred embodiment, the apparatus comprises at least one hopper for storing the feedstock. Preferably, the hopper comprises dispensing means for dispensing a predetermined amount of the feedstock, wherein the predetermined amount comprises the amount of feedstock required to rotationally mould at least one load-carrying apparatus.

Preferably, the apparatus further comprises filling means for loading the mould with a predetermined amount of the feedstock.

Preferably, the filling means comprises means for filling the feedstock via a series of apertures in the outer mould portion.

Preferably the means for filling the feedstock comprises at least one bucket having a series of apertures corresponding to the series of apertures in the outer mould portion.

More preferably, the bucket comprises a telescopic bucket having an adjustable length. This may enable the bucket to be transported to the moulding apparatus more easily.

In a preferred embodiment, the heating means comprises at least one gas burner.

Preferably, the cooling means comprises a jet of water. The water may be cycled through a cooling system or may be provided from a reservoir, for example from the sea.

According to a further aspect, there is provided a unifier for promoting binding and dispersion of a mineral filler and a polymer, wherein the unifier comprises a fatty acid amide.

Preferably, the fatty acid amide comprises a straight or branched C_{12}-C_{24} fatty acid amide. More preferably, the unifier comprises steramide.

In a preferred embodiment, the unifier further comprises an external lubricant, preferably wherein the external lubricant comprises a stearate.

Preferably, the unifier comprises more than 80% by weight external lubricant. More preferably, the unifier comprises about 90% by weight external lubricant.

Preferably, the mineral filler comprises a silicate or a carbonate material, more preferably the filler comprises sand or calcium carbonate.

According to a further aspect, there is provided a rotationally-moulded load-carrying apparatus comprising:
at least 10% by weight HDPE;
at least 10% by weight of a filler comprising sand;
a unifier comprising a fatty acid amide;
wherein the load-carrying apparatus comprises an inner layer and an outer layer, the layers having different compositions.

In one embodiment, the apparatus comprises an elongate container having a length of at least about 5m and a wall thickness of at least about 40mm.

In one embodiment, the apparatus comprises a pallet having a length of at least about 800mm.

Preferably, the inner layer comprises a foamed layer.

Aspects may be provided separately or in combination and features of one aspect may be applied to other aspects. Modifications, which would be obvious to one skilled in the art, may further be provided within the scope of the invention.

Embodiments of the invention will now be described with reference to the drawings in which:

Fig. 1 illustrates a container and moulding apparatus according to one embodiment;

Figs. 2a and 2b are schematic diagrams of a further embodiment of a moulded container and moulding apparatus according to one embodiment;

Fig. 3 is a schematic diagram of a further embodiment of a moulded container and moulding apparatus according to one embodiment;

Fig. 4 illustrates a further embodiment of moulding apparatus according to one embodiment;

Fig. 5 is a schematic diagram of a container according to one embodiment;

Fig. 6 illustrates one embodiment of a container manufactured according to the methods and apparatus described herein;

Fig. 7 is a schematic diagram of a reinforcing eyelet according to one embodiment;

Fig. 8 is a schematic diagram of a reinforcing eyelet moulded into a container according to one embodiment;

Fig. 9a is a schematic perspective view of the top of one embodiment of a pallet manufactured according to the methods and apparatus described herein;

Fig. 9b is a schematic perspective view of the bottom of one embodiment of a pallet manufactured according to the methods and apparatus described herein;

Fig. 10 is a schematic diagram of a pallet according to one embodiment;

Fig. 11 is a schematic diagram of a manufacturing plant for implementing the methods described herein;

Fig. 12 is a further schematic diagram of a manufacturing plant for implementing the

methods described herein;

Fig. 13 is a schematic diagram illustrating the loading of feedstock into a moulding apparatus according to one embodiment;

Fig. 14 illustrates example moulding cycle times for a plastics-based filled compared to polyethylene;

Fig. 15 illustrates example impact strengths for a plastics-based filled compared to polyethylene;

Fig. 16 illustrates example tensile modulus results for a plastics-based filled material compared to polyethylene.

A method of manufacturing an embodiment of a container, pallets, cable reels, and other similar apparatus using rotational moulding techniques will now be described in more detail. This method is applicable to a wide range of products manufactured from plastics based materials and is not limited to the storage and transportation products described.

Conventional rotational moulding techniques are well known in the art. A feedstock is inserted into a preformed mould. The mould is then placed into an oven to melt the feedstock and the mould is rotated and tilted to cover the interior of the mould with a layer of the melted feedstock. The rotation of the mould may be performed using a spider having a plurality of legs, for example three legs, wherein a mould may be attached to and rotated relative to each leg of the spider and wherein the spider as a whole may also be rotated. Once this stage of the process is complete, the mould is then cooled, for example by removing it from the oven or by cooling the oven itself. During the cooling process, the mould continues to be rotated to ensure it remains evenly coated. Once cooled, the product may be removed from the mould for further processing.

For some applications, rotational moulding may be preferable to, for example, blow moulding or injection moulding, since the process introduces fewer stresses into the moulded product. In addition, components can be incorporated into the rotationally

moulded product by positioning the components within the mould before the rotational moulding process begins. The prior art rotational moulding process, however, is slow and inefficient. Each moulding cycle requires a large amount of time to allow the oven to heat to the required temperature and to cool the mould at the end of the heating process. In addition, a large amount of energy is wasted in the heating and cooling cycle.

To alleviate some of the problems with conventional rotational moulding techniques discussed above a new rotational moulding technique and apparatus will now be described with reference to Fig. 1. The apparatus and methods described herein may be used to form all of the products described herein.

As in a conventional rotational moulding technique, the product is preferably formed within a mould 110. The inner surface of the mould is preferably formed with a shape corresponding to the required outer shape of the product, for example a container with a corrugated outer surface may be formed using a mould with a corresponding corrugated inner surface. In the present embodiment, the apparatus further includes an inner mould portion 112, or liner, placed within the outer mould portion 110, hence the product 114 is formed between the surfaces of the inner mould portion 112 and the outer mould portion 110.

In a preferred embodiment, the apparatus described herein is formed substantially in a single moulding operation, for example, the main body of the freight container may be formed in a single piece. Hence a large mould may be required, for example to encompass a container that meets the 40' high-cube specification. Large moulds may also be used to mould a plurality of products in a single moulding operation, for example a number of pallets may be moulded in a single mould. In the case of a container, the container is formed around the outer surface of the inner mould portion 112. In the case of smaller products, such as a pallet, each product is formed between the surfaces of the inner 112 and outer 110 moulds.

To mould the product, a predetermined amount of the feedstock is placed within the

apparatus between the inner and the outer mould portions and the mould is heated. The walls of the mould may be heated by any suitable heating means, for example using heating plates embedded in the walls of the mould but, in the present embodiment, the mould is heated by applying direct heating means 118, for example a plurality of gas burners, to the exterior of the mould walls. The mould may then be rotated through the gas burners 118 to heat the mould walls evenly and hence obtain an even thickness of the plastics-based material over the walls of the mould. In the present embodiment, the gas burners are coupled to a bar 116 and the bar is maintained at a constant distance from the mould walls by spring elements. This may ensure that the walls of the mould are heated evenly and to a constant temperature. The compositions described herein may be softened at a temperature of about 160° and may be melted at a temperature of about 220°.

The inner surface of the inner mould portion 112, or liner, is preferably further heated by a gas burner within the liner 120. Hence both the outer mould portion 110 and the liner 112 are evenly heated. This may enable an even distribution of plastics-based feedstock within the mould.

Probes 122 within the mould monitor the temperature inside the mould to determine when the feedstock has melted. Probes 112 may be positioned within the inner mould portion 112 of the apparatus and may monitor the air temperature within the inner mould portion.

A heat shield may further be provided to reflect heat from the gas burners onto the surface of the apparatus.

Figs. 2a, 2b, Fig. 3 and Fig. 4 illustrate further embodiments of apparatus for performing the method described herein. The mould 210 is supported on a carriage 212, which may enable the mould to be rocked and rotated, or spun, to coat the whole of the mould, between the outer mould portion and the inner mould portion, with a layer of the feedstock. It has been found that the surfaces of the mould may be coated sufficiently using only a low rate of rotation and only a small angle of

tilting. For example, a rotation rate of about 4 rotations per minute and a tilt cycle rate of about 2 cycles per minute with a maximum angle of inclination of 15° may be sufficient to distribute the melted feedstock over the surfaces of the mould.

Once the interior surface of the mould has been coated, the gas burners may be turned off and the mould may be cooled, for example by rotating the mould through a stream or jet of water or of air. Alternatively, the mould may be cooled using a cooling jacket, for example a water-cooled or oil-cooled jacket.

If a layered product is required, however, it is not necessary to cool the coated mould. Instead, further feedstock may be introduced to the mould, for example a feedstock having a different composition may be introduced, and the mould may continue to be rotated until the second layer of feedstock has covered the inner surface of the first, outer layer. Further layers of material may continue to be added in this way to build up the product.

If there is no inner mould portion in the apparatus, the feedstocks for the further layers may simply be added to the inside of the mould, however, if the first outer layer of the product is formed over the surfaces of an outer and an inner mould portion, it will be appreciated that any further feedstock for a further, inner layer of the product must be inserted within the skin or shell of the outer layer. In the present embodiment, this is achieved by providing areas of the outer mould portion that are covered in a coating to which the melted feedstock does not adhere, as shown at 124 in Fig. 1. For example, for a polyethylene composition, areas on the inner surface of the outer mould portion may be covered with a Teflon (RTM) coating. The non-stick areas of the mould may be removable from the mould leaving apertures 124, preferably small apertures, through the outer mould portion and through the skin formed by the first feedstock, to the interior of the skin formed by the first feedstock. A further feedstock may then be added to the interior of the skin formed by the first feedstock to provide an inner layer for the product. For a container, non-stick areas are preferably provided at diametrically opposite corners of the container mould.

It will be appreciated that it is advantageous to insert the second feedstock into the interior skin of the first feedstock as quickly as possible after the first feedstock has coated the surfaces of the mould. This may allow a better bond to be formed between the two layers and may reduce the cycle time for manufacturing the product. Methods and apparatus for fast and efficient insertion of the second feedstock will be described in more detail below.

As outlined above, it has been found that it is not necessary to cool each layer of the product within the mould before adding a further layer. Rather, simply adding the next layer allows a secure bond to be formed between the layers of the product without significant mixing or blending occurring between the layers.

Once all of the required layers have been added, the mould and the product within the mould may be cooled, preferably by rotating the mould through a jet or stream of water. To decrease the time for the cooling part of the cycle, the cooling means may be applied both to the exterior surface of the outer mould portion and to the interior surface of the inner mould portion.

The methods described above may allow a product, such as a container, or a batch of products, such as a batch of pallets, to be manufactured in a cycle time of about 20 minutes.

Other methods of moulding or forming the products described herein, such as the container, may be used and the products may be moulded in several sections, which may subsequently be joined together. For example, the doors of the container may be moulded separately and then may be joined to the main part of the container. In the present embodiment, the main body of the container and the doors of the container may each be provided with corresponding parts that may be assembled into a piano-type hinge. The two parts of the hinge may be manufactured as part of the door and the main body and the door may be coupled to the main body of the container by inserting a rod through corresponding sections of the hinges.

An embodiment of the container itself will now be described in more detail with reference to Figs. 5 and 6. According to one embodiment, the container is formed as a 40' high-cube container with each wall comprising an outer skin layer 510 and an inner layer 512.

Each layer of the walls of the container comprises a filled plastics-based material containing plastic, a filler and a unifier material, but the relative amounts of the components of the material vary between layers. The outer skin layer 510 preferably comprises a larger proportion of a high-quality plastics material, such as polyethylene, for example the plastics material may comprise about 60% by weight of the composition, and a smaller proportion of a filler, for example about 40% by weight of the composition. The inner layer 512 preferably contains a relatively high proportion of the filler material, for example about 60% by weight and the foam layer is preferably highly foamed, for example 50% foamed. The foaming ingredient may be, for example, Sodium Bicarbonate. The total thickness of the container walls may be about 60mm, but this may be varied depending on the requirements of the container. In one embodiment, the thickness of the outer skin layer may be about 5-8mm and the thickness of the inner layer may be about 40-60mm. In one embodiment, the walls of the container may be only 30mm thick.

In an alternative embodiment, the inner layer 512 may be formed with a low proportion of filler material or may include no filler material. For example, the inner layer 512 may comprise a plastics material and a foaming agent. In one embodiment, the outer skin layer 510 may comprise a high proportion of filler, for example about 60% by weight filler.

The filler material of the present embodiment is sand, preferably dredged sand, since this has finer particles than desert sand. Alternative filler materials may include ash, a carbonate material such as calcium carbonate, another silicate material such as ground rock, or a salt material such as sodium chloride or an organic material, such as straw, peanut hulls, vegetable waste, miscanthus, wood flour or animal

droppings.

The net weight of embodiments of containers as described above may be about 3000 kilograms, preferably about 2800 kilograms, although heavier or lighter containers may also be formed using the techniques described herein. The net weight of a prior art steel container is about 3800-4200 kilograms, so containers as described herein may provide a significant saving in weight, for example on a container ship on which a large number of containers may be transported.

Preferably, the exterior surfaces of the container are not flat surfaces but have raised sections or corrugations 514 as shown in Fig. 5. In addition, the lower surface of the container may be formed with a raised grid of bars, for example in a waffle pattern. This may provide additional strengthening to the lower surface of the container, which may support the majority of the weight of the contents of the container and may further be required to support the weight of loading machinery, such as a fork-lift truck, which may be driven inside the container to load the contents.

An embodiment of a model of a 40 foot container formed according to the methods described herein is illustrated in Fig. 6.

Non-plastic components or pre-formed components may be incorporated into the container during its manufacture. For example, a steel frame may be incorporated into the container by placing the steel frame within the mould and forming the plastic layers of the container around the steel frame. Including a steel frame in the container may increase the strength of the container and may allow weight to be distributed evenly throughout the container structure. It is noted, however, that it has been found that it is not necessary to include a steel frame in embodiments of the container described herein to enable the container to meet the requirements of the industry standards.

Reinforcing eyelets may further be provided in some embodiments of the container,

preferably in the four corners of the container, by over-moulding the eyelets into the plastic composition during the moulding process. An embodiment of a reinforcing eyelet is illustrated in Fig. 7. Fig. 8 illustrates one embodiment of an eyelet incorporated into a container manufactured according to the methods and apparatus described herein. The reinforcing eyelets may be used to connect the container to lifting apparatus, such as lifting gantries, and may provide additional strength to the container at these points.

A door fastening or locking mechanism may further be incorporated into the container. Preferably, the door mechanism may be moulded so that is it within the container. The door mechanism preferably comprises a prior art door mechanism as used for the prior art steel containers.

Preferably, the cycle time for manufacturing a container body as described herein, with an outer skin layer and an inner layer, is about 20mins. The container is preferably heated at a carefully controlled rate to ensure that the container walls are of an even thickness and is preferably further cooled at a carefully controlled rate to ensure that the container walls do not become distorted.

In a further embodiment of the container described herein, a fibrous material may be incorporated into the container to further bind the composition and strengthen the container, particularly when it is subjected to tensional or bending forces.

A further product which may be manufactured using the methods and apparatus described herein is a pallet. An embodiment of a pallet is illustrated herein in Figs. 9a and 9b. Traditionally, pallets are manufactured from wood, but a pallet manufactured according to the methods described herein may provide a number of advantages over a prior art wooden pallet. In particular, the usable life of a pallet described herein may be greater than that of a wooden pallet and the present pallets may be more environmentally sustainable than wooden pallets. Freight distributors often do not use wooden pallets more than once to ensure that each pallet used is in good condition for transporting the goods. In addition, it is often not economical to

repair broken wooden pallets, since the cost of repair often exceeds the cost of a new pallet.

Figs. 9a and 9b illustrate one embodiment of a pallet, although it will be appreciated that a wide variety of shapes and sizes of pallets may be formed using the methods described herein. The pallet illustrated in Figs. 9a and 9b comprises a platform 910, on which the goods to be transported may be placed or stacked, and a plurality of feet 912. In this embodiment, the pallet comprises nine feet spaced in a regular pattern over the bottom surface of the pallet. The pallet illustrated is a rectangular two-way access pallet, but rectangular or square pallets may be formed and may be designed as four-way access pallets to enable machinery, such as a fork-lift truck, to access and move the pallet from any one of four directions.

Optional bracing members 914 may be provided between some or all of the feet of the pallet as shown in Fig. 9b, however the bracing members are not a necessary feature of the pallet.

The feet of the pallet may contain recesses or hollows, so may not be whole. This may reduce the weight of the pallet.

The pallet is preferably manufactured using a rotational moulding technique. Preferably, a plurality, or batch, of pallets is formed in a single moulding operation. The inner surface of the outer mould portion of the apparatus may be formed with a plurality of indentations, corresponding to the feet of the pallet, and the surface of the inner mould portion of the apparatus may be formed as a flat surface, to provide a pallet with a flat pallet surface to be formed. Alternatively, indentations or texture may be provided on the surface of the inner mould portion to allow a pallet with an uneven or textured platform surface to be formed.

A further embodiment of a pallet is illustrated in Fig. 10. In a preferred embodiment, the pallet comprises an outer skin surface 1010 comprising about 60% by weight of a plastics material, such as polyethylene, preferably HDPE, about 40% by weight of

a filler material, such as sand or calcium carbonate, and a small amount of a unifier material. Once the outer skin has been formed in the moulding apparatus, a second foam composition 1012 may be inserted into the outer skin using the method described above, and the inner foam material 1012 may be distributed throughout the outer skin 1010. The foam composition may be introduced as a solid material but may start to foam on the application of heat to the material. In the present embodiment, the foamed material may be 50% foamed.

In one embodiment, the pallet may comprise a single, solid plastics-based filled material and may not include a foam layer. However, including a foam layer may enable the finished pallet to be lighter and may add strength to the pallet when compared to a solid pallet manufactured with indentations to reduce the amount of plastics-based material used.

Further products may be manufactured using the methods and compositions described herein. For example, fencing or screening material may be provided in sheet form, with or without a foam layer. Building materials, for example panels that may be used as internal or external walls or components that may be used for decking, may further be provided. Similarly, the methods and compositions described may be used to provide ship-building materials, such as a hull for a ship, boat or tanker.

In some embodiments, a plurality of layers may be provided in a product and each layer may comprise a different composition. For example, the upper and lower surfaces of the outer skin layer described herein may be formed separately in different moulding cycles and may be formed from different compositions. In some embodiments, non-plastics based layers, for example metals-based layers, may be incorporated into the product.

The methods described above may be implemented in a moulding plant and an embodiment of a plant is illustrated in Figs. 11 and 12. However, it will be appreciated that a wide variety of manufacturing plants may be used and the plants

may be adapted depending on the product being manufactured. The plastics composition feedstocks may be mixed within the plant, or may be mixed and delivered to the plant as raw materials, for example in pellet form. Preferably, the feedstock may be formed by mixing the components and forming pellets from the mixed components. Preferably, the unifier may be mixed with the filler before the polymer is added to the mixture.

The plant illustrated in Fig. 11 includes a central container area 1110 comprising a plurality of containers 1112, each containing a preformed feedstock. A plurality of mobile feedstock machines 1114 obtain a predetermined quantity of feedstock from the central containers 1112 and deliver them to each of a plurality of moulding apparatus 1116.

As illustrated in Figs. 12 and 13, the feedstock machines 1210 insert the feedstock into the moulding apparatus 1212. It has been found that it is advantageous to tilt the moulding apparatus 1212 to enable the feedstock to be delivered efficiently to the moulding apparatus 1212. The feedstock machines 1210 are preferably provided with telescopic arms 1214 and telescopic delivery buckets 1216 for delivering the feedstock to the moulding apparatus 1212 along the whole length of the apparatus. This may be particularly advantageous when inserting the second feedstock into the moulding apparatus 1212, since inserting the feedstock along the whole length of the apparatus may enable the feedstock to be inserted more quickly into the apparatus, while the first feedstock is relatively fluid. The telescopic delivery bucket 1216 preferably extends to a length of about 12m, so it may extend the whole length of a container mould, and preferably holds a predetermined amount of feedstock. Preferably, the bucket 1216 is divided into a plurality of sections, each of which holds a predetermined amount of feedstock.

Properties of compositions described herein will now be outlined in more detail. The description below is provided by way of example only and the compositions and parameters provided are not intended to be limiting. The mouldings described were carried out under the following moulding conditions:

Oven temperature = 300 C
Rotation ratio ≈ 4:1
Cooling medium = Forced air
Sheet steel test mould

All cycle times are taken from the same start and end point to allow for easier comparisons of the various stages in the internal air temperature traces. For each moulding carried out, Polyethylene was mixed with sand in a 50:50 mixture by mass. To this mixture, different levels of unifier were added from 1 % by weight to 10% by weight.

The polyethylene grade used was a rotomoulding grade, RG 7243 produced by Borealis in Norway, this material is a standard LLDPE grade with a density of 924kg/m^3 and a MFI of 4.5.

Grade	Cycle Time (min)
T963	20.17
T964	22.35
T965	21.7
T966	22.77
T967	22.05
T968	22.87
T969	22.06
T970	22.07
T971	23.23
T972	22.94
Polyethylene	33.23

It can be seen from the data above that the cycle time of each filled moulding is not affected by the addition of different levels of unifier but there is a substantial difference between the filled and the polyethylene mouldings. It is assumed that

difference is due to the filled mouldings containing half the amount of PE as the polyethylene mouldings.

Standard tensile test specimens were produced from the filled mouldings using a die. The specimens were tested on an Instron 4411 tensile testing machine at a crosshead speed of 20 mm/min (as per standard ASTM 638). The data provided below shows the mechanical properties of each of the grades tested. A standard unmodified polyethylene grade is also added as a comparison.

Grade	Stress at Break (MPa)	Strain at Break (%)	Modulus (MPa)
T963	1.95	21.9	172.0
T964	2.13	22.4	141.6
T965	1.65	17.7	131.0
T966	1.68	13.3	153.0
T967	2.10	21.5	142.9
T968	1.16	8.2	121.6
T969	2.52	19.7	108.7
T970	2.24	20.5	113.4
T971	1.17	11.3	128.5
T972	1.05	9.6	101.2
Standard	--	--	223

There is a lot of scatter in the values of the mechanical properties determined for all the grades tested. However, the general trend shows a decrease in modulus as the percentage of unifier is increased.

Figs. 14, 15 and 16 illustrate graphically the properties of the filled compared to polyethylene as described above.

As will be appreciated by one skilled in the art, aspects of the invention may provided independently and features of one aspect may be applied to other aspects. It will also be appreciated that the methods described herein may be used to

manufacture a wide range of products and the invention is not limited to the products described herein.

Claims:

1. A rotationally-moulded load-carrying apparatus for carrying a load of at least 50 kilograms, wherein the apparatus is manufactured substantially from a filled plastics material comprising:
at least 10% by weight of a polymer;
at least 10% by weight of a mineral filler material.

2. Apparatus according to Claim 1 wherein the mineral filler material comprises a silicate material, preferably sand.

3. Apparatus according to Claim 1 wherein the mineral filler material comprises a carbonate material, preferably calcium carbonate.

4. Apparatus according to Claim 1, 2 or 3 wherein the polymer comprises polyethylene, preferably wherein the polymer comprises High Density Polyethylene (HDPE).

5. Apparatus according to any preceding claim wherein the material comprises at least 25% by weight filler.

6. Apparatus according to any preceding claim wherein the material comprises at least 25% by weight polymer.

7. Apparatus according to any preceding claim wherein the material comprises from about 30% to about 70% by weight polymer and from about 70% to about 30% by weight filler.

8. Apparatus according to any preceding claim wherein the filled plastics material further comprises a unifier.

9. Apparatus according to Claim 8 wherein the filled plastics material comprises

at least about 0.1% by weight unifier.

10. Apparatus according to Claim 8 or 9 wherein the filled plastics material comprises less than about 10% by weight unifier.

11. Apparatus according to any of Claims 8 to 10 wherein the filled plastics material comprises at least about 0.25% by weight unifier.

12. Apparatus according to any of Claims 8 to 11 wherein the filled plastics material comprises less than about 5% by weight unifier.

13. Apparatus according to any of Claims 8 to 12 wherein the unifier is pre-mixed with the filler.

14. Apparatus according to Claim 8 wherein the unifier comprises an internal lubricant.

15. Apparatus according to Claim 14 wherein the internal lubricant comprises a fatty acid amide.

16. Apparatus according to Claim 15 wherein the internal lubricant comprises a straight or branched C_{12}-C_{24} fatty acid amide.

17. Apparatus according to any of Claims 14 to 16 wherein the internal lubricant comprises steramide.

18. Apparatus according to any of Claims 14 to 17 wherein the unifier further comprises an external lubricant, preferably wherein the external lubricant comprises a stearate.

19. Apparatus according to any of Claims 14 to 18 wherein the unifier comprises less than 20% by weight internal lubricant.

20. Apparatus according to any of Claims 14 to 19 wherein the unifier comprises about 10% by weight internal lubricant.

21. Apparatus according to any preceding claim wherein the filler comprises at least one of:
a silicate material, preferably sand;
ash;
a carbonate material, preferably calcium carbonate;
a salt, preferably sodium chloride.

22. Apparatus according to any preceding claim wherein the apparatus is rotationally moulded substantially in one piece.

23. Apparatus according to any preceding claim wherein the apparatus comprises a freight container.

24. Apparatus according to Claim 23 wherein the freight container comprises an elongate freight container having a length of at least 5m.

25. Apparatus according to Claim 23 or 24 wherein the freight container comprises an elongate freight container having a length of at least 10m.

26. Apparatus according to any preceding claim wherein the filler comprises a light-coloured material.

27. Apparatus according to any of Claims 1 to 22 wherein the apparatus comprises a pallet.

28. Apparatus according to Claim 27 wherein the pallet is moulded substantially in one piece.

29. Apparatus according to Claim 27 or 28 wherein the pallet comprises a platform and a plurality of feet depending from the platform.

30. Apparatus according to Claim 29 wherein the feet of the pallet are regularly spaced over the lower surface of the platform.

31. Apparatus according to Claim 29 or 30 wherein the feet are arranged to enable lifting equipment to engage the pallet from any one of four directions.

32. Apparatus according to any of Claims 29 to 31 wherein at least one foot is arranged substantially at each corner of the platform of the pallet.

33. Apparatus according to any of Claims 29 to 32 wherein at least one foot is arranged substantially at the centre of the platform of the pallet.

34. Apparatus according to any of Claims 29 to 33 wherein at least one foot is arranged substantially at the centre of each edge of the platform of the pallet.

35. Apparatus according to any of Claims 29 to 34 wherein the feet of the pallet are moulded integrally with the platform.

36. Apparatus according to any of Claims 29 to 35 wherein each foot has a recess in the lower surface of the foot.

37. Apparatus according to any of Claims 27 to 36 wherein the pallet comprises an outer skin layer having an upper surface and a lower surface.

38. Apparatus according to Claim 37 wherein the upper and lower surfaces of the outer skin layer are arranged to abut each other over at least a portion of the pallet surface.

39. Apparatus according to Claim 37 or 38 wherein the pallet further comprises

an inner layer having a different composition to the outer skin layer.

40. Apparatus according to Claim 39 wherein the inner layer comprises a foaming agent.

41. Apparatus according to Claim 39 or 40 wherein the inner layer comprises at least 40% by weight of a filler.

42. Apparatus according to any of Claims 27 to 41 wherein the pallet has a length of at least 800mm.

43. Apparatus according to any of Claims 1 to 22 wherein the apparatus comprises a cable reel.

44. Apparatus according to any preceding claim wherein the apparatus comprises a plurality of layers.

45. Apparatus according to Claim 44 wherein the composition of the filled plastics material differs between the layers.

46. Apparatus according to Claim 44 or 45 wherein the composition of a first layer of the apparatus is optimised to provide an outer skin layer.

47. Apparatus according to Claim 46 wherein the outer skin layer comprises more than about 50% by weight polymer.

48. Apparatus according to Claim 46 or 47 wherein the outer skin layer comprises about 60% by weight polymer.

49. Apparatus according to any of Claims 44 to 48 wherein the composition of a second layer of the apparatus is optimised to provide an inner layer.

50. Apparatus according to Claim 49 wherein the inner layer comprises a polymer.

51. Apparatus according to Claim 49 or 50 wherein the inner layer comprises a polymer and a filler.

52. Apparatus according to Claim 51 wherein the inner layer comprises more than about 30% by weight filler.

53. Apparatus according to Claim 51 or 52 wherein the inner layer comprises more than about 50% by weight filler.

54. Apparatus according to any of Claims 51 to 53 wherein the inner layer comprises about 60% by weight filler.

55. Apparatus according to any of Claims 51 to 54 wherein the inner layer comprises a greater amount of filler by weight than the outer layer.

56. Apparatus according to any of Claims 51 to 55 wherein the inner layer comprises a foaming agent, preferably wherein the foam layer is about 50% foamed.

57. Apparatus according to any preceding claim wherein the filled plastics material further comprises a pigment.

58. Apparatus according to any preceding claim wherein the apparatus incorporates a remotely readable ID tag, preferably an RFID tag.

59. Apparatus according to Claim 58 wherein the ID tag is moulded into the surface of the apparatus.

60. Apparatus for sealing a freight container comprising sealing means

manufactured from a plastics material, wherein the plastics material is soluble in salt-water.

61. Apparatus according to Claim 60 wherein the plastics material comprises PVA or PVOH.

62. Apparatus according to Claim 60 or 61 wherein the plastics material further comprises a filler and/or a unifier.

63. A method of manufacturing apparatus for storage or transportation of loads greater than about 50 kilograms, the method comprising rotationally moulding the apparatus from a filled plastics material comprising a polymer, a filler and a unifier.

64. X-ray apparatus for forming an X-ray of the contents of a load-carrying apparatus for carrying loads of at least 50 kilograms and manufactured from a filled plastics material, comprising:
a scanning area;
energy delivery means for providing energy of a suitable frequency spectrum and intensity to penetrate at least 20mm of the filled plastics material;
energy detecting means to detect reflected energy.

65. Thermal imaging apparatus for forming a thermal image of the contents of a load-carrying apparatus for carrying loads of at least 50 kilograms and manufactured from a filled plastics material, comprising:
a scanning area;
energy detection means for detecting thermal energy transmitted from within the load-carrying apparatus.

66. Apparatus according to Claim 64 or 65 wherein the scanning area has a maximum dimension of at least 1m.

67. Apparatus according to any of Claims 64 to 66 wherein the scanning area has a maximum dimension of at least 2m.

68. Apparatus according to any of Claims 64 to 67 wherein the filled plastics material comprises at least 10% by weight of a mineral filler.

69. Apparatus according to any of Claims 64 to 68 wherein the load-carrying apparatus comprises a freight container.

70. Apparatus according to any of Claims 64 to 69 wherein the load-carrying apparatus has a length of at least 5m.

71. Apparatus according to any of Claims 64 to 70 wherein the load-carrying apparatus has a length of at least 10m.

72. A method of rotationally moulding a product from a filled plastics material comprising:
providing a mould for the product defining a void corresponding to at least a portion of the required shape of the product;
loading a first feedstock having a first composition comprising a polymer and at least 10% by weight of a mineral filler into the mould;
heating the mould;
rotating and/or rocking the mould about at least two axes to coat the internal walls of the mould with a layer of the first feedstock;
cooling the mould;
releasing the product from the mould.

73. A method according to Claim 72 further comprising providing heating means adjacent to the walls of the mould and heating the mould using the heating means.

74. A method according to Claim 72 or 73 further comprising providing cooling

means adjacent to the walls of the mould and cooling the mould using the cooling means.

75. A method according to any of Claims 72 to 74 wherein the heating means comprises a plurality of burners.

76. A method according to any of Claims 72 to 75 wherein the cooling means comprises at least one supply of water.

77. A method according to any of Claims 72 to 76 wherein the mould is a generally elongate mould and wherein the method comprises rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and rocking the mould about a second axis substantially orthogonal to the first axis.

78. A method according to any of Claims 72 to 77 wherein rocking the mould comprises rocking the mould to a maximum angle of less than about 30° from the horizontal.

79. A method according to any of Claims 72 to 78 wherein rocking the mould comprises rocking the mould at a rate of less than about 6 rocking cycles per minute.

80. A method according to any of Claims 72 to 79 wherein rotating the mould comprises rotating the mould at a rate of less than about 10 revolutions per minute.

81. A method according to any of Claims 72 to 80 wherein the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion.

82. A method according to Claim 81 further comprising providing heating means within the inner mould portion.

83. A method according to any of Claims 72 to 82 further comprising maintaining the heating means at a substantially constant distance from the walls of the outer mould portion as the mould is rotated.

84. A method according to any of Claims 72 to 83 further comprising, before cooling the mould:
loading a second feedstock having a second composition into the mould;
rotating the mould to form a second layer of the second feedstock.

85. A method according to any of Claims 72 to 84 wherein the composition of the first layer is optimised to provide an outer skin layer.

86. A method according to Claim 84 or 85 wherein the composition of the second layer is optimised to provide an inner layer.

87. A method according to any of Claims 84 to 86 wherein the second feedstock comprises a foaming agent.

88. A method according to any of Claims 84 to 87 wherein the second feedstock comprises a higher proportion of filler than the first feedstock.

89. A method according to any of Claims 72 to 88 wherein the product comprises at least one of: a freight container, a pallet, a cable reel or a panel.

90. A method according to any of Claims 72 to 89 further comprising positioning elements of the product within the mould before the feedstock is inserted and over-moulding the elements into the product.

91. A method according to Claim 90 wherein the product comprises a freight container and wherein the elements comprise one or more of:
a metal frame;
door securing means;
strengthening elements; or
corner lifting elements.

92. A method according to any of Claims 72 to 91 wherein the product is moulded substantially in one piece.

93. A method according to any of Claims 72 to 92 wherein releasing the product from the outer mould portion comprises moving the walls of the outer mould portion apart and away from the moulded product.

94. A filled plastics material comprising:
a polymer;
at least 10% by weight of a mineral filler;
a unifier comprising stearate.

95. A filled plastics material according to Claim 94 wherein the unifier further comprises an internal lubricant, preferably steramide.

96. A filled plastics material according to Claim 95 wherein the steramide comprises Chrodamide S Powder.

97. A filled plastics material according to any of Claims 94 to 96 wherein the stearate comprises Calcium Stearate.

98. A filled plastics material according to any of Claims 94 to 97 wherein the unifier comprises more than 5% by weight steramide.

99. A filled plastics material according to any of Claims 94 to 98 wherein the

unifier comprises about 10% by weight steramide.

100. A filled plastics material according to any of Claims 94 to 99 wherein the unifier comprises more than 80% by weight stearate.

101. A filled plastics material according to any of Claims 94 to 100 wherein the unifier comprises about 90% by weight stearate.

102. A filled plastics material according to any of Claims 94 to 101 wherein the polymer comprises polyethylene.

103. A filled plastics material according to any of Claims 94 to 102 wherein the polymer comprises High Density Polyethylene (HDPE).

104. A filled plastics material according to any of Claims 94 to 103 wherein the filler comprises at least one of:
a silicate material, preferably sand;
ash;
a carbonate material, preferably calcium carbonate;
a salt, preferably sodium chloride.

105. A filled plastics material according to any of Claims 94 to 104 wherein the filled plastics material comprises at least 0.5% by weight unifier.

106. A filled plastics material according to any of Claims 94 to 105 wherein the filled plastics material comprises about 1% by weight unifier.

107. Apparatus for rotationally moulding, from a filled plastics material, a load-carrying apparatus for carrying a load of at least 50 kilograms, the apparatus comprising:
a mould defining a void corresponding to at least a portion of the required shape of the product;

means for receiving a first feedstock comprising a filled plastics material comprising a polymer and at least 10% by weight of a mineral filler;
heating means;
cooling means;
means for rotating and/or rocking the mould about at least two axes.

108. Apparatus according to Claim 107 wherein the heating means are provided adjacent to the walls of the mould.

109. Apparatus according to Claim 107 or 108 wherein the cooling means are provided adjacent to the walls of the mould.

110. Apparatus according to any of Claims 107 to 109 wherein the mould is a generally elongate mould and wherein the apparatus further comprises means for rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and means for rocking the mould about a second axis substantially orthogonal to the first axis.

111. Apparatus according to any of Claims 107 to 110 wherein the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion.

112. Apparatus according to any of Claims 107 to 111 further comprising heating means within the mould.

113. Apparatus according to any of Claims 107 to 112 further comprising means for maintaining the heating means at a substantially constant distance from the mould.

114. Apparatus according to any of Claims 107 to 113 wherein the mould has a

length of at least 5m.

115. Apparatus according to any of Claims 107 to 114 wherein the mould has a length of at least 10m.

116. Apparatus according to any of Claims 107 to 115 wherein the apparatus is mounted over a pit and wherein at least one end of the mould is rocked into the pit.

117. Apparatus according to any of Claims 107 to 116 wherein the means for receiving the feedstock comprises a series of apertures in the outer mould portion.

118. Apparatus according to Claim 117 wherein the series of apertures is formed along at least one edge of the outer mould portion.

119. Apparatus according to Claim 117 or 118 to wherein the series of apertures is covered by at least one sliding gate valve.

120. Apparatus according to any of Claims 117 to 119 wherein the internal surface of the sliding gate valve is coated in a non-stick material.

121. Apparatus according to any of Claims 107 to 120 further comprising at least one hopper for storing the feedstock.

122. Apparatus according to Claim 121 wherein the hopper comprises dispensing means for dispensing a predetermined amount of the feedstock, wherein the predetermined amount comprises the amount of feedstock required to rotationally mould at least one load-carrying apparatus.

123. Apparatus according to any of Claims 107 to 122 further comprising filling means for loading the mould with a predetermined amount of the feedstock.

124. Apparatus according to Claim 123 wherein the filling means comprises means for filling the feedstock via a series of apertures in the outer mould portion.

125. Apparatus according to Claim 124 wherein the means for filling the feedstock comprises at least one bucket having a series of apertures corresponding to the series of apertures in the outer mould portion.

126. Apparatus according to Claim 125 wherein the bucket comprises a telescopic bucket having an adjustable length.

127. Apparatus according to any of Claims 107 to 126 wherein the heating means comprises at least one burner.

128. Apparatus according to any of Claims 107 to 127 wherein the cooling means comprises a supply of water.

129. A unifier for promoting binding and dispersion of a mineral filler and a polymer, wherein the unifier comprises a fatty acid amide.

130. A unifier according to Claim 129 wherein the fatty acid amide comprises a straight or branched C_{12}-C_{24} fatty acid amide.

131. A unifier according to Claim 129 or 130 wherein the unifier comprises steramide.

132. A unifier according to any of Claims 129 to 131 further comprising an external lubricant, preferably wherein the external lubricant comprises a stearate.

133. A unifier according to Claim 132 comprising more than 80% by weight external lubricant.

134. A unifier according to Claim 132 or 134 comprising about 90% by weight external lubricant.

135. A rotationally-moulded load-carrying apparatus comprising:
at least 10% by weight HDPE;
at least 10% by weight of a filler comprising sand;
a unifier comprising a fatty acid amide;
wherein the load-carrying apparatus comprises an inner layer and an outer layer, the layers having different compositions.

136. Apparatus according to Claim 135, wherein the apparatus comprises an elongate container having a length of at least about 5m and a wall thickness of at least about 40mm.

137. Apparatus according to Claim 136, wherein the apparatus comprises a pallet having a length of at least about 800mm.

138. Apparatus according to any of Claims 135 to 137 wherein the inner layer comprises a foamed layer.

139. Apparatus substantially as any one described herein or as illustrated in any of Figs. 1 to 13.

140. A method substantially as any one described herein with reference to any of Figs. 1 to 13.

141. A filled plastics material substantially any one as described herein.

142. A container, a pallet, a mould or an assembly station substantially as any one herein described.

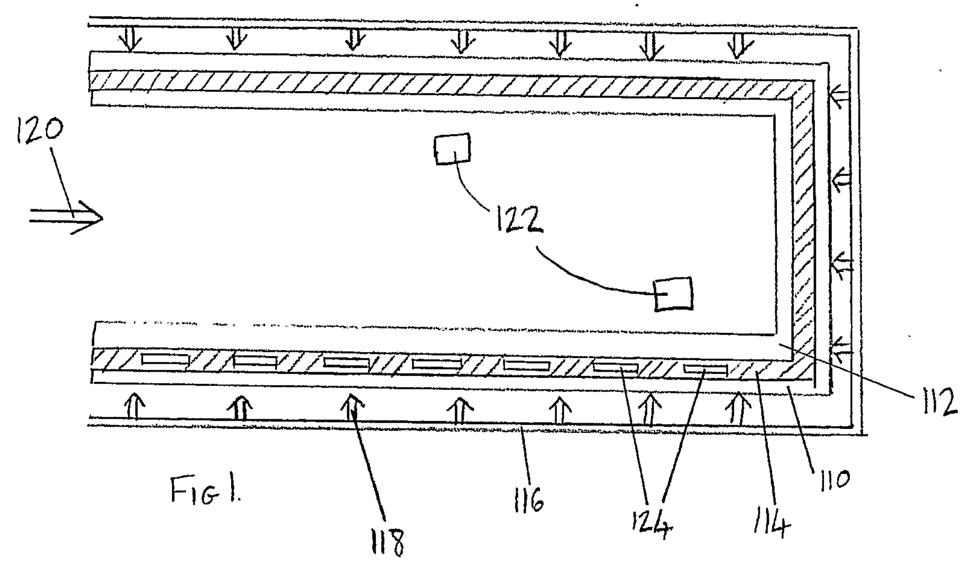

FIG 1.

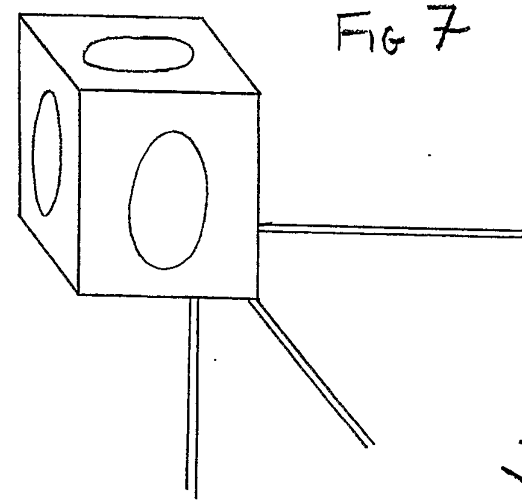

FIG 7

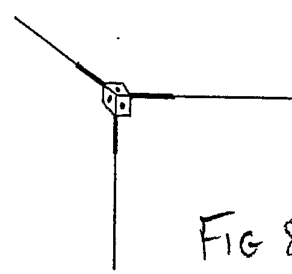

FIG 8

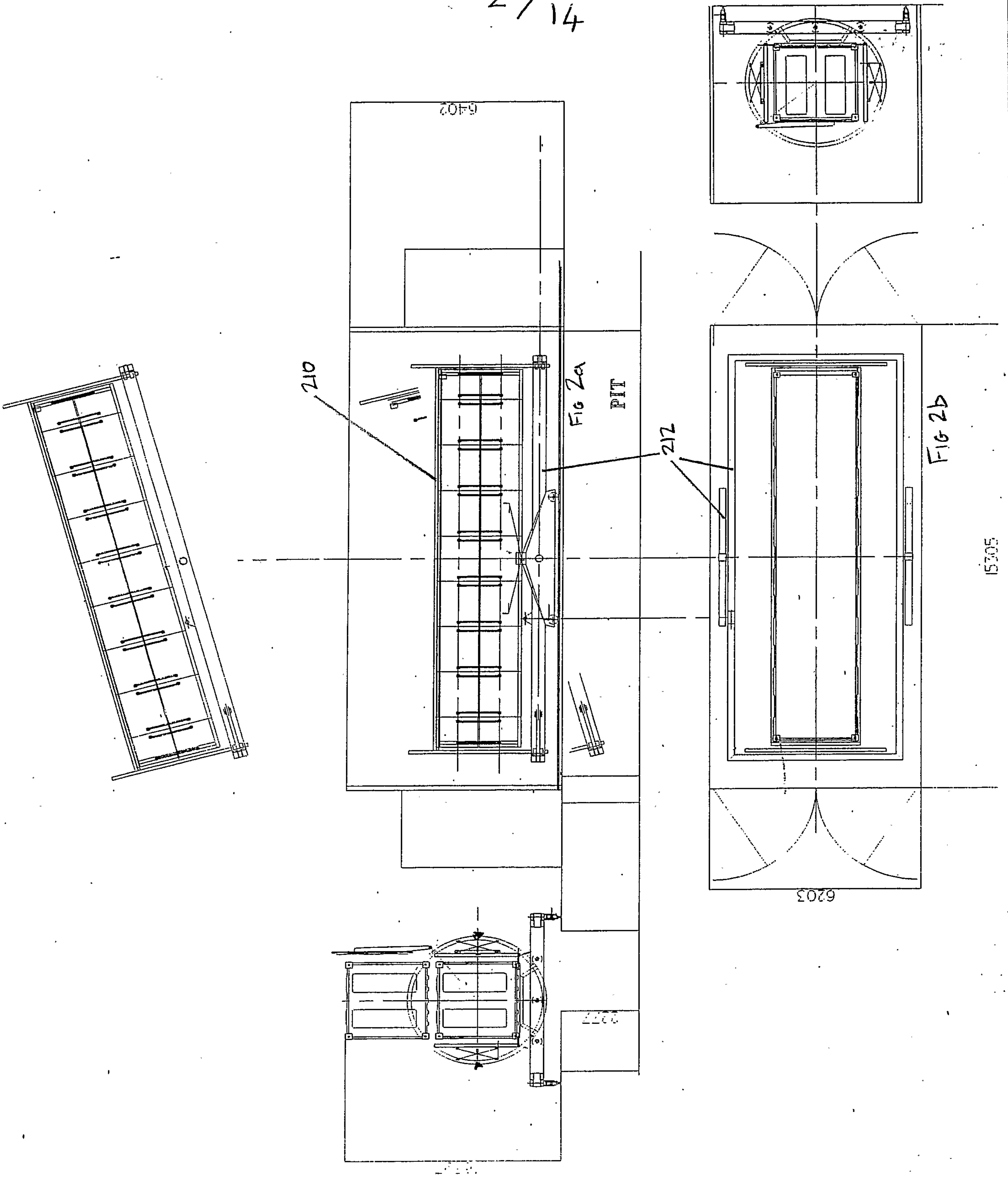

Fig 2a

Fig 2b

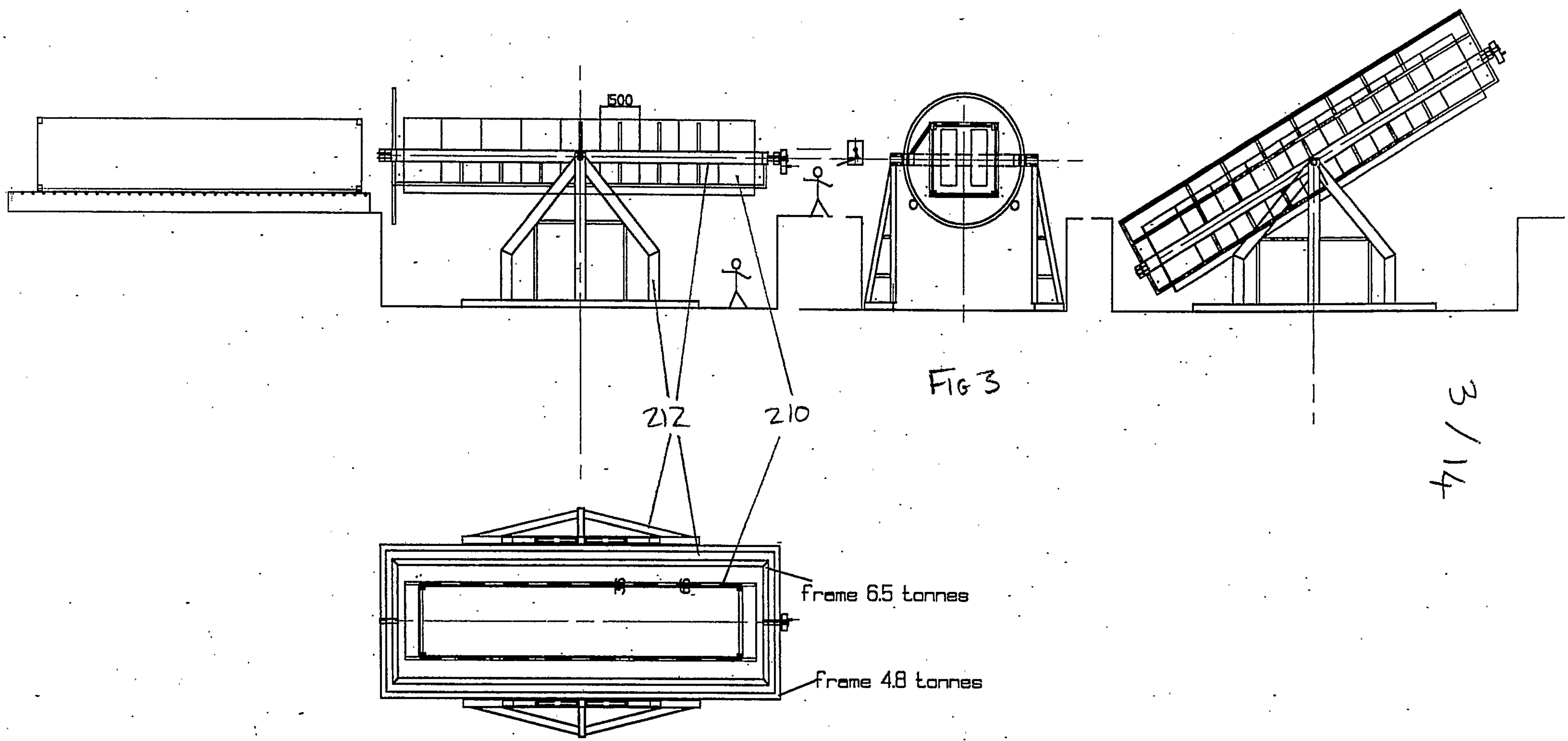

FIG 3

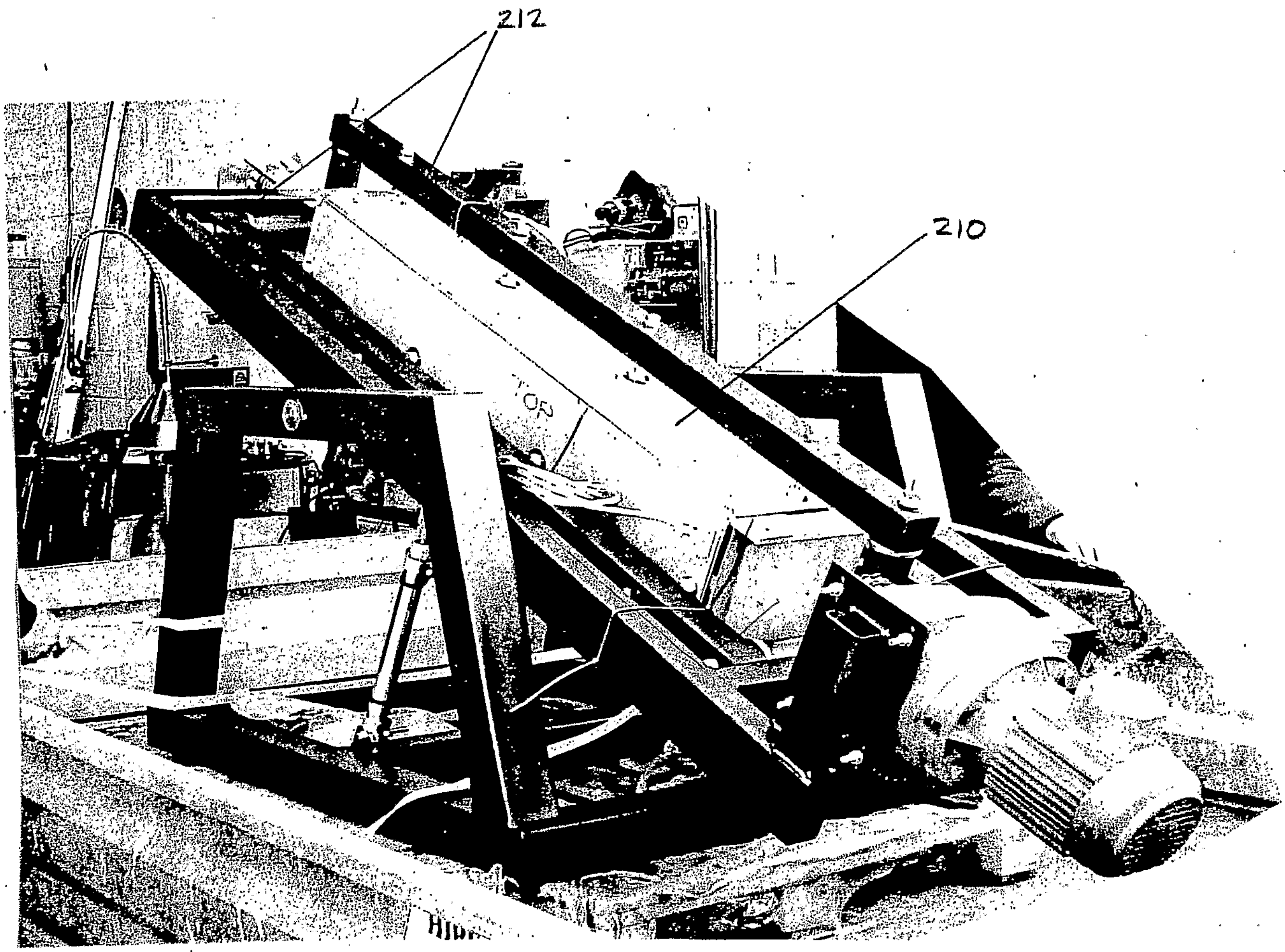

FIG 4

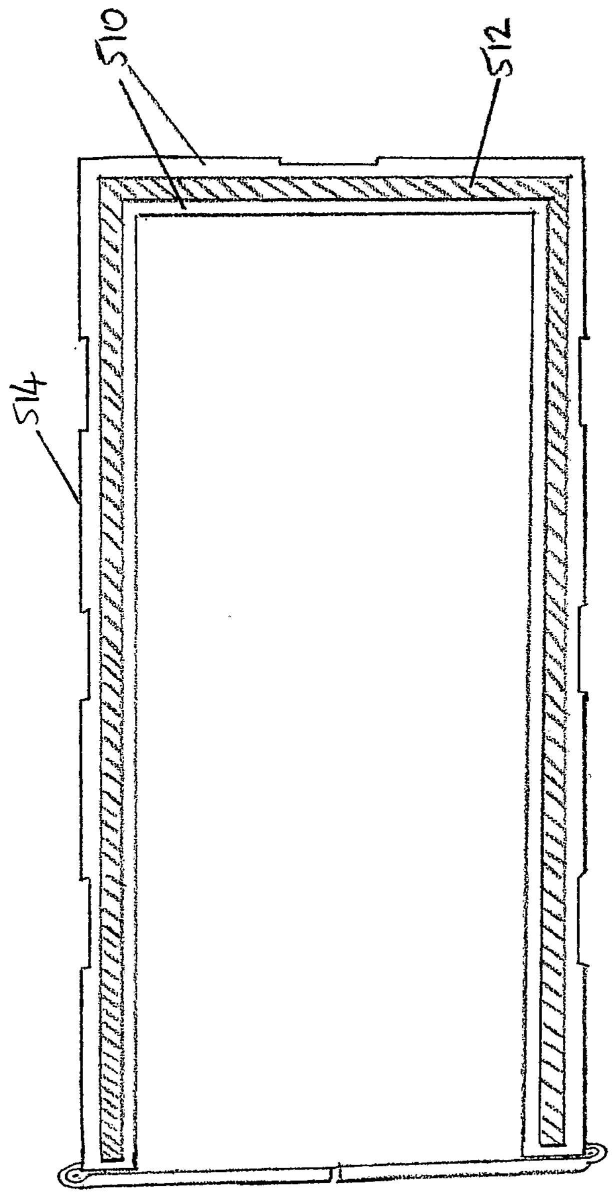

Fig 5

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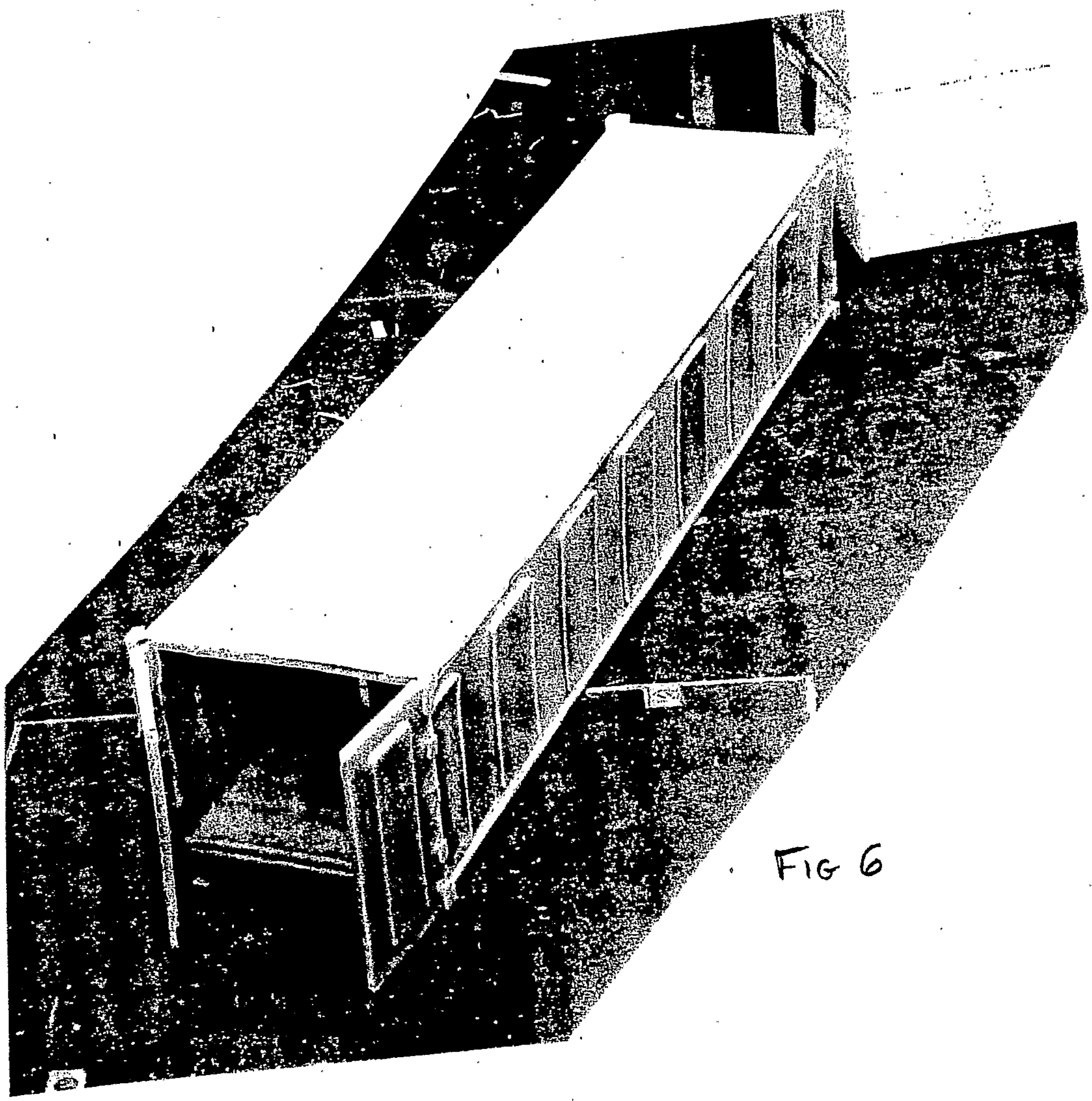

FIG 6

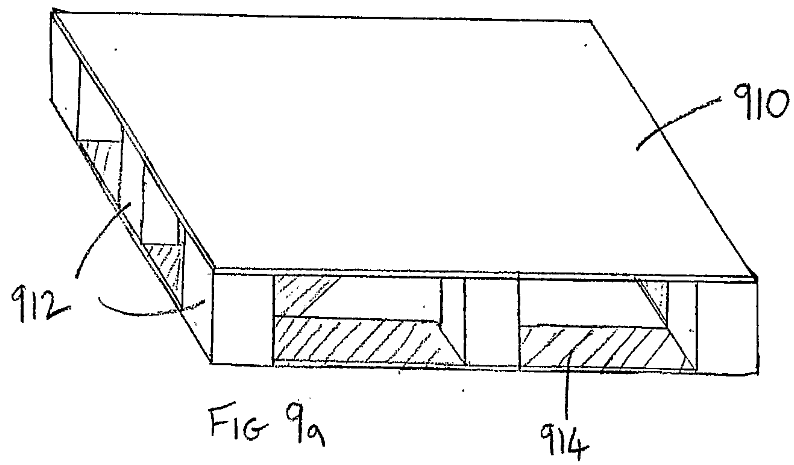

FIG 9a

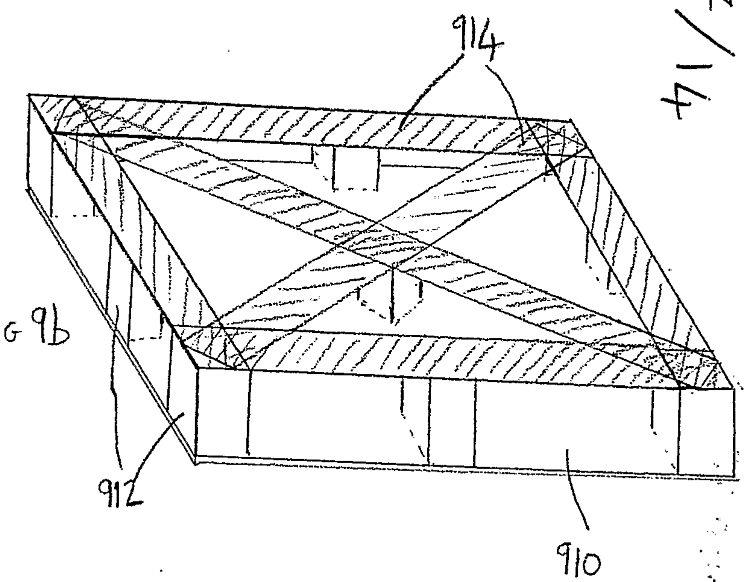

FIG 9b

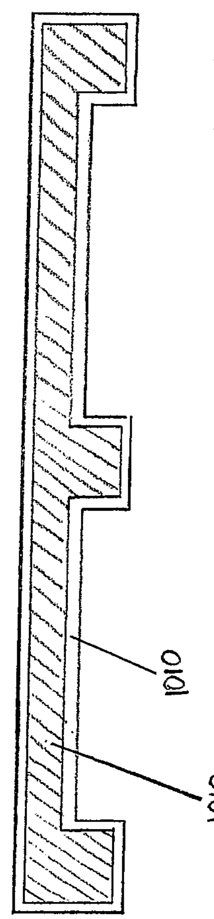

FIG 10

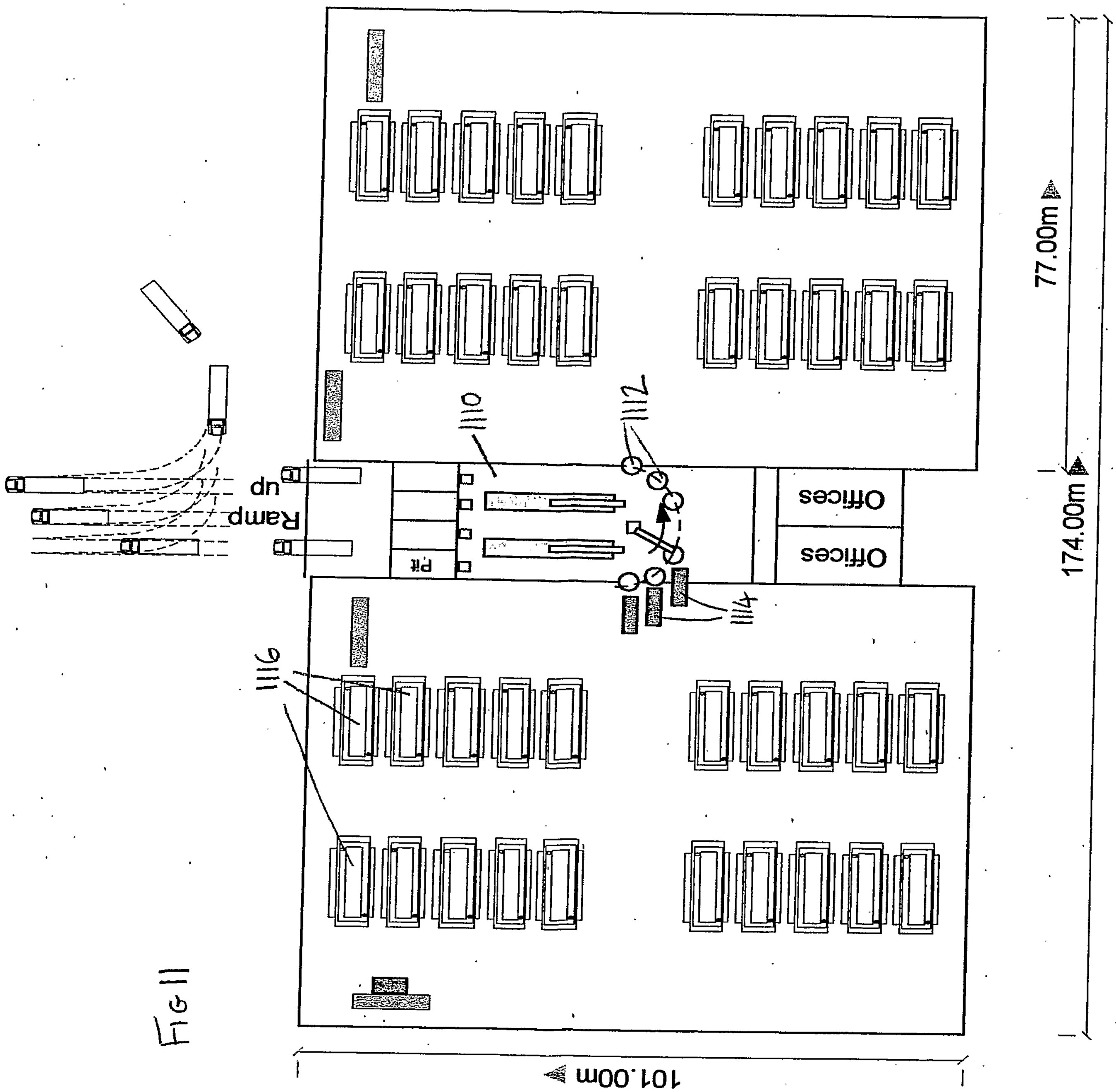
77.00m
174.00m
Offices
Offices
Ramp
up
Pit
1110
1112
1114
1116
101.00m

FIG 11

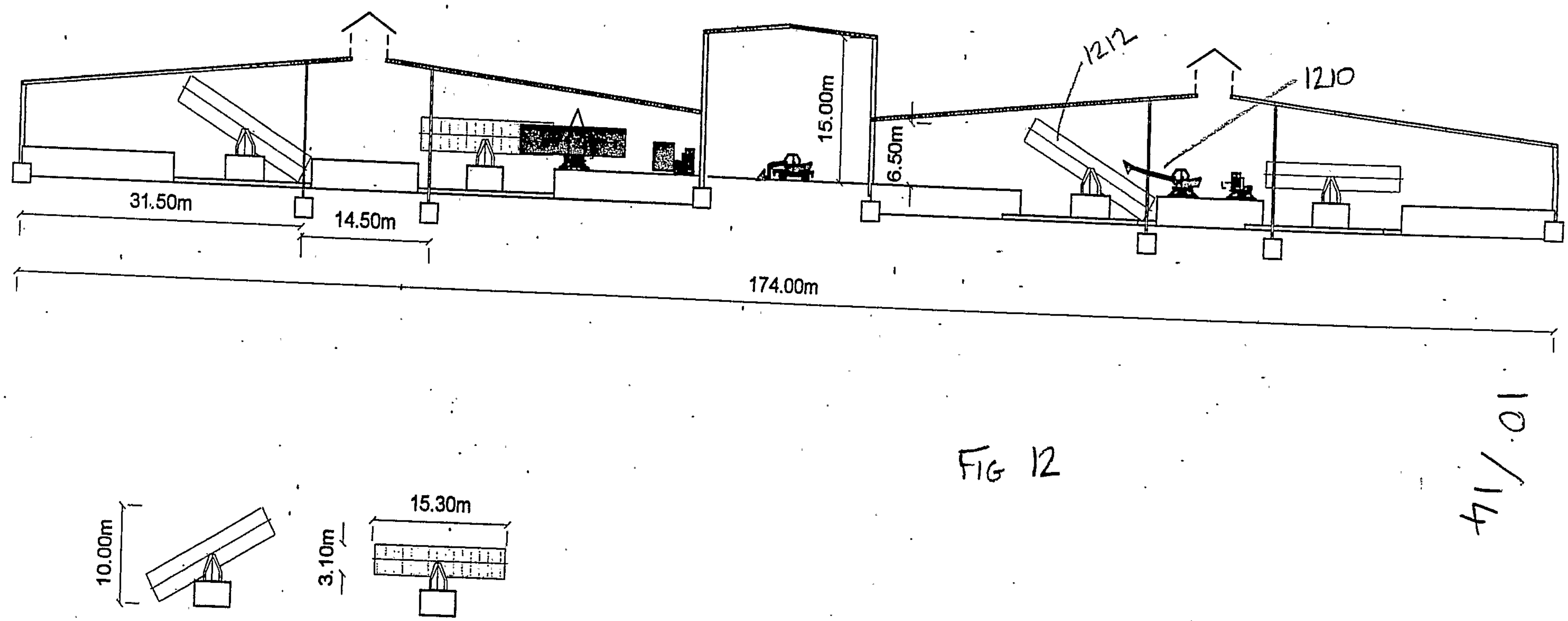

FIG 12

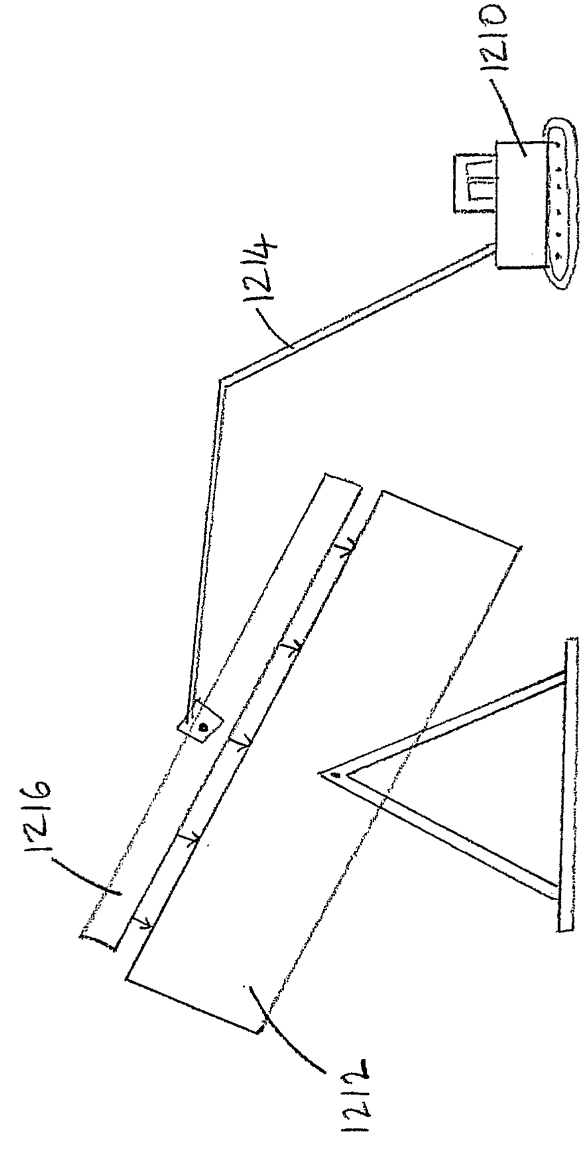

FIG 13

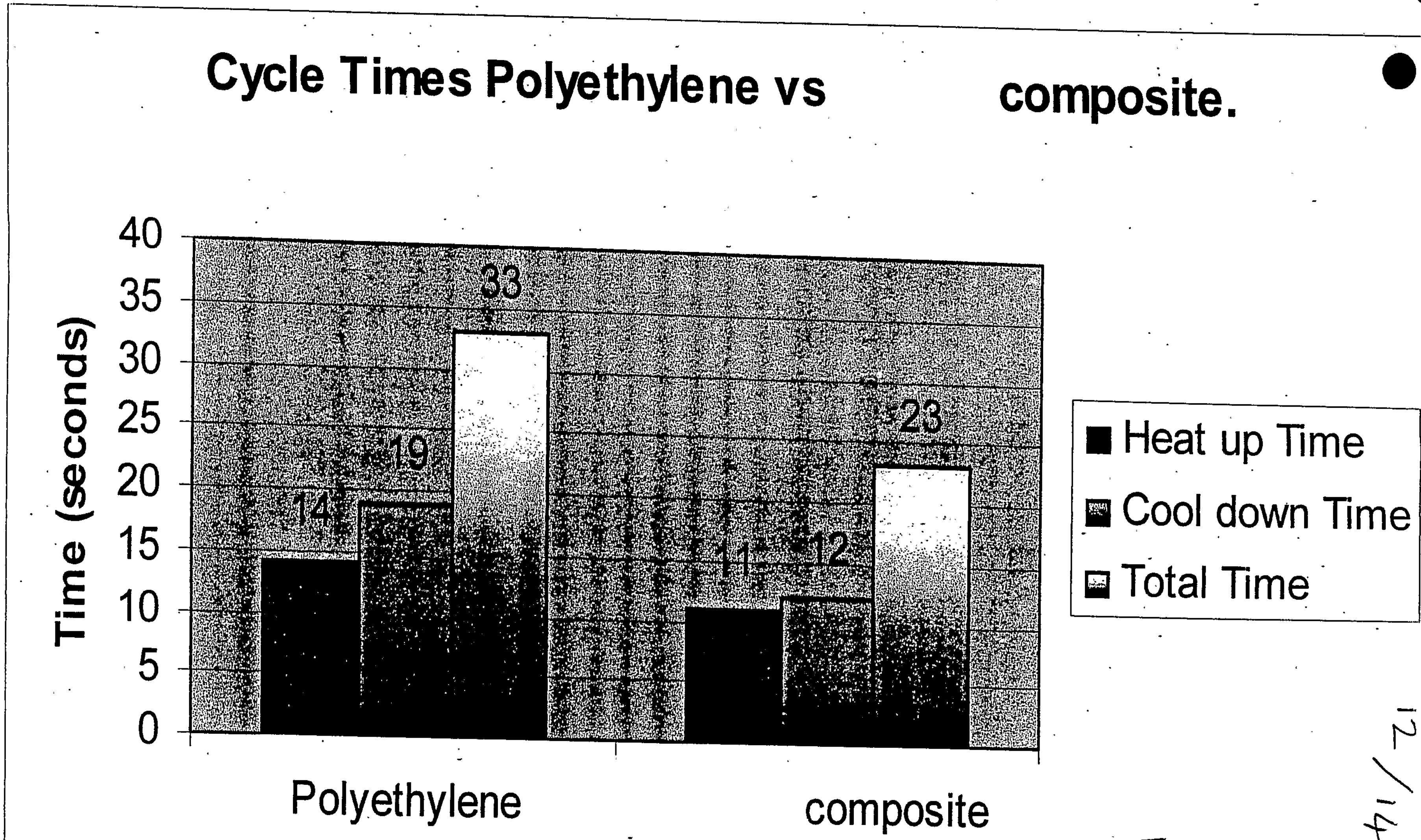
Cycle Times Polyethylene vs composite.
Time (seconds)
40
35
30
25
20
15
10
5
0
14
19
33
11
12
23
Polyethylene
composite
Heat up Time
Cool down Time
Total Time

FIG 14

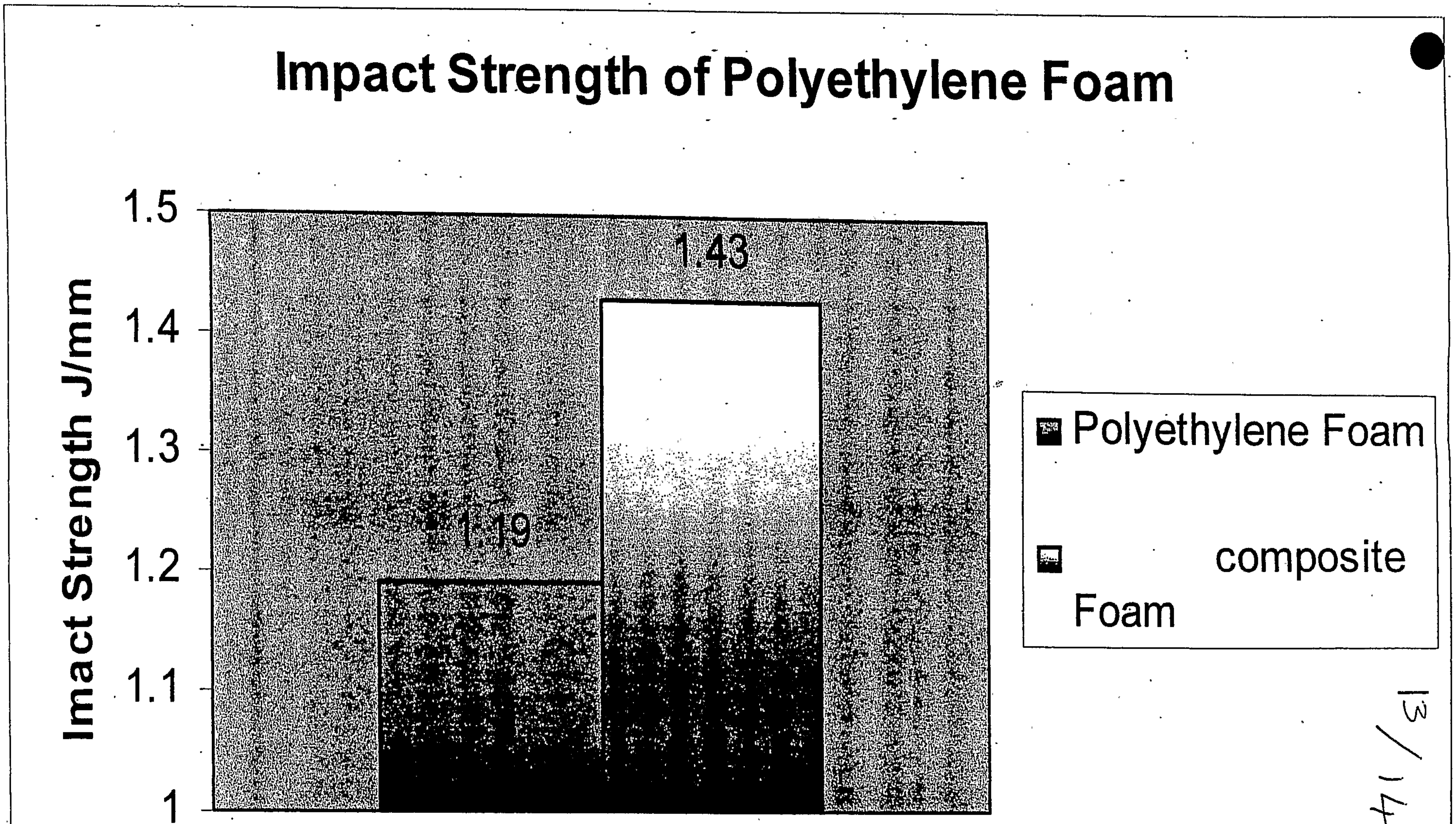
Impact Strength of Polyethylene Foam
Imact Strength J/mm
1.5
1.4
1.3
1.2
1.1
1
1.19
1.43
Polyethylene Foam
composite Foam

FIG 15

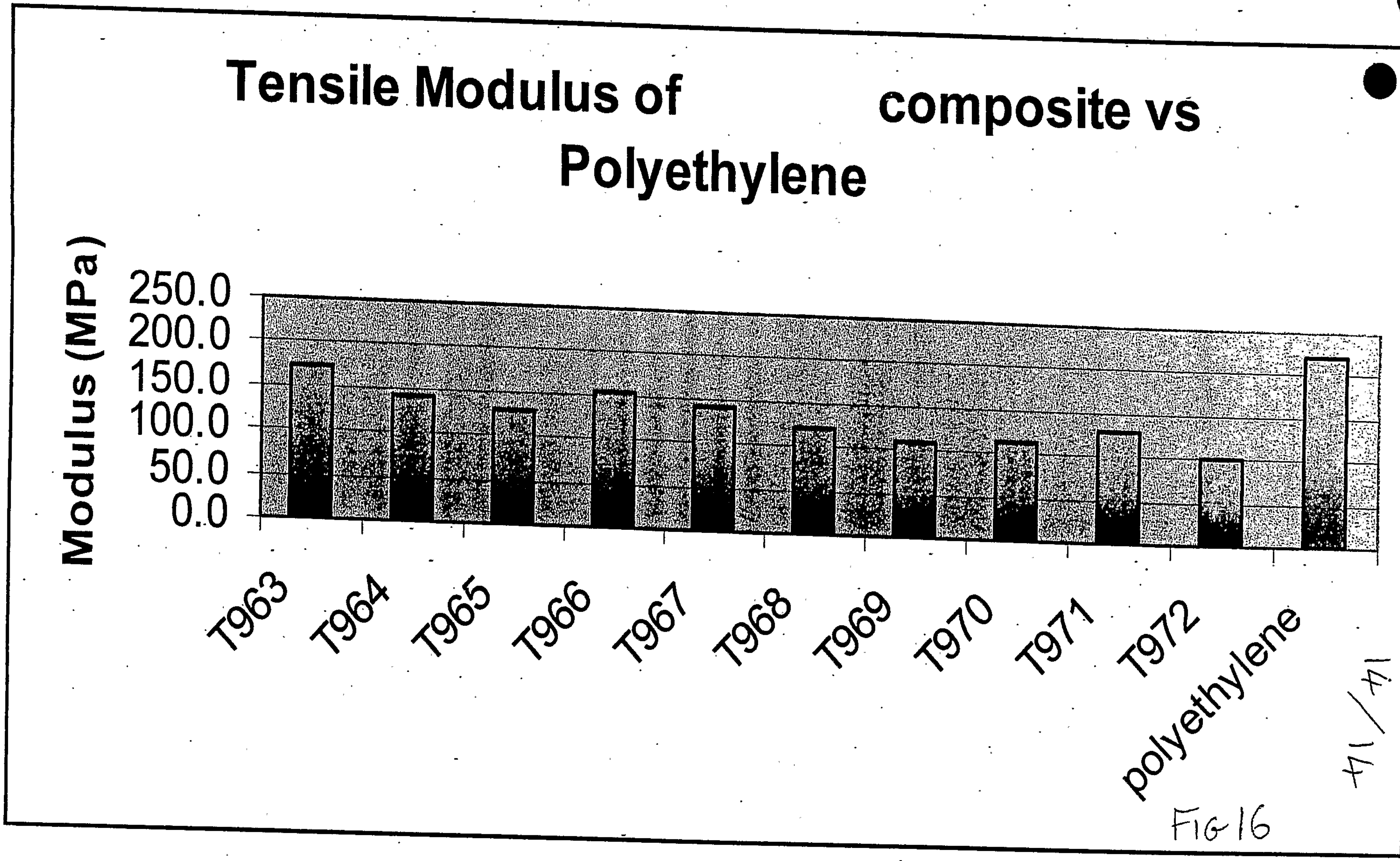
Tensile Modulus of composite vs Polyethylene
Modulus (MPa)
250.0
200.0
150.0
100.0
50.0
0.0
T963
T964
T965
T966
T967
T968
T969
T970
T971
T972
polyethylene

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FIG 16